

EXHIBIT 81

UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF MICHIGAN
SOUTHERN DIVISION

In re Flint Water Cases

Civil Action No. 5:16-cv-10444-JEL-MKM (consolidated)

Hon. Judith E. Levy
Mag. Mona K. Majzoub

Elnora Carthan, et al. v. Governor
Rick Snyder, et al.

Civil Action No. 5:16-cv-10444-JEL-MKM

**DECLARATION OF HOWARD HU, M.D., M.P.H., Sc.D., IN SUPPORT OF
PLAINTIFFS' MOTION FOR CLASS CERTIFICATION**

I, Howard Hu, M.D., M.P.H., Sc.D., state and declare as follows:

I. INTRODUCTION

1. My name is Howard Hu. I am a resident of Seattle, Washington. I am providing this Declaration In Support of Plaintiffs' Motion for Class Certification at the request of counsel. I am legally competent to provide this Declaration.

2. I have been retained as a public health, epidemiology and medical expert on behalf of a putative subclass of children in the City of Flint who were exposed to, and ingested, Flint Water during the period of May 1, 2014

through January 5, 2016. I have been asked to evaluate whether such children suffered adverse health impacts as a result of the Flint Water Crisis and, if so, whether the existence of such adverse health impacts could be established using a methodology that is common to the subclass of children. Assuming that the answer to these questions is “yes”, I have also been asked to illustrate the nature of those injuries through presentation of different modeled “exemplar” levels of exposure.

II. QUALIFICATIONS

3. I am a physician-scientist, internist and preventive medicine specialist, with a doctoral degree in epidemiology. As my *Curriculum Vitae* (attached as Exhibit 1) reflects, my current academic appointments are Affiliate Professor in the University of Washington and Adjunct Professor in the University of Michigan. In 2017-2018, while on sabbatical from the University of Toronto, I was a Visiting Scholar at the University of Washington before transitioning into my current temporary position. On July 1, 2020, I will be transitioning again into my next permanent position, as a tenured Professor, Chair of the Department of Preventive Medicine, and occupant of the Flora L. Thornton Endowed Chair, Keck School of Medicine at the University of Southern California. Previously, I had been the Founding Dean of the Dalla Lana School of Public Health and Professor of

Environmental Health, Epidemiology, Global Health, and Medicine (tenured), University of Toronto (2012-2017); the National Sanitation Foundation (NSF) International Endowed Chair of the Department of Environmental Health Sciences, Professor of Environmental Health, Epidemiology and Medicine (tenured), Founding Director of the U.S. National Institute for Environmental Health Sciences (NIEHS) Environmental Health Core Sciences Center, and Associate Physician at the University of Michigan and University of Michigan Health System (2006-2012); and Professor of Occupational & Environmental Medicine (tenured), Founding Director of the NIEHS Center for Children's Environmental Health, Director of the Occupational Medicine Residency at the Harvard School of Public Health and Associate Physician in the Brigham & Women's Hospital in Boston (1988-2006).

4. I received my M.D. degree from the Albert Einstein College of Medicine in New York City in 1982, a Masters of Public Health in Occupational Health from the Harvard School of Public Health in 1982, a Master of Science in Epidemiology from the Harvard School of Public Health in 1986, and a Doctorate of Science in Epidemiology from the Harvard School of Public Health in 1990. I am certified as a Diplomate by the American Board of Internal Medicine and as a Diplomate in Occupational Medicine by the

American Board of Preventive Medicine. I was an Associate Professor of Medicine at the Harvard Medical School and a tenured Professor in the Department of Environmental Health at the Harvard School of Public Health until 2006 when I moved to Michigan to become Chair of the Department of Environmental Health Sciences and a tenured Professor at the University of Michigan School of Public Health. A more complete statement of my credentials is contained in my *curriculum vitae*, a copy of which is attached as Exhibit 1.

5. In terms of specific scientific expertise, since 1990, I have led multi-institutional and international teams of scientists, students and fellows devoted to investigating the environmental, nutritional, social, psychosocial, genetic and epigenetic determinants of chronic disease and impaired child development in population-based studies in the U.S., Mexico, India (where I was a senior faculty Fulbright Scholar, 2000-2001), China, and elsewhere around the world. Our research team's work has generated over 300 publications in the peer-reviewed literature and won several awards, such as the 1999 Progress and Achievement Award from the NIEHS, the 2009 Linus Pauling Lifetime Achievement Award, the 2011 Award of Excellence from the American Public Health Association, and the 2015 John Goldsmith Award for Outstanding Contributions from the International Society for

Environmental Epidemiology. In my current position, I am continuing NIEHS-funded environmental birth cohort research while also co-leading the Global Burden of Disease-Population Health initiative, which aims to improve understanding of pollution's "footprint" on the global burden of disease. In terms of service that capitalizes on my expertise, I served on, among other entities, the Board of Population and Public Health Practice of the Institute of Medicine of the National Academy of Sciences; on the Board of Environmental Studies and Toxicology of the National Research Council; on the External Advisory Council of NIEHS; and I am currently serving as the senior epidemiologist on the Energy Research Committee of the Health Effects Institute.

6. In terms of expertise and service specific to lead exposure and toxicity, I note that over 200 of my publications in the peer-reviewed literature have focused on investigations of lead exposure and resulting impacts on health, including research relevant to IQ, other aspects of cognition, behavior, educational attainment, physical growth and blood pressure. For the last 20 years, I have authored the Chapter on "Heavy Metals" for each edition (including the most recent 2018 edition) of Harrison's Principles of Internal Medicine, one of the most-widely read and authoritative textbooks in the world. As a clinician, I have also been the primary consultant in

occupational/environmental medicine for over 100 cases of suspected lead toxicity and have served as the Grand Rounds discussant or lecturer on the subject of lead toxicity in leading universities around the world.

7. I have served on various scientific expert panels relating to lead for various state and federal agencies. For example, I was a member of the Ad Hoc Expert Panel to Form Medical Management Guidelines for Lead-exposed Adults for the National Institute of Occupational Safety and Health. I was a member of the Working Group on Lead and Pregnancy for the United States Centers for Disease Control. I served on the Scientific Advisory Board for the Massachusetts Division of Occupational Hygiene in connection with its lead registry project. I have served as an expert peer reviewer of U.S. government reports related to lead, such as the 2007 edition of the *Toxicological Profile of Lead* produced by the Agency for Toxic Substances and Disease Registry of the U.S. Centers for Disease Control and Prevention, and the U.S. Environmental Protection Agency's (EPA) National Center for Environmental Economics Office of Policy's draft report on *Concentration-Response Functions between Lead Exposure and Adverse Health Outcomes for Use in Benefits Analysis: Cardiovascular-Disease Related Mortality*. I have also received grants from various federal agencies relating to my work on the health effects of lead, including grants from the NIEHS for my work

on measuring lead burden and childhood lead, grants from the NIEHS on the metabolic effects of pregnancy and lactation on lead burden, a grant from the National Institute of Occupational Safety and Health in connection with the Carpenters' Lead Project, a grant from the Office of Research on Women's Health of the U.S. National Institutes of Health (NIH) relating to lead and hypertension in women, among other grants. In total, I've received peer-reviewed, competitively-awarded grants in excess of \$25 million for research projects directly related to the health effects of lead from NIEHS and/or NIH. I have taught and continue to teach and give lectures on health effects of lead exposure.

8. The principles and methodology I employed in forming my opinion are based on a review of and utilization of insights gained from peer-reviewed scientific literature that are relevant to the task at hand; the interpretation and utilization of publicly available data and data obtained in the discovery process that are relevant to the task at hand; and the reliance on the expert declarations of colleagues (Dr. Larry Russell, Dr. Clifford Weisel, Dr. Panos Georgopoulos, Dr. Pierre Goovaerts and Dr. Bruce Lanphear) involved in this matter who have undertaken rigorous assessments related to exposure to lead from the Flint Water Crisis. It is standard generally-accepted methodology for physicians, epidemiologists and toxicologists to rely on exposure

assessments prepared by other scientists who specialize in providing such assessments. Exposure assessments may be based on testing results, but in the absence of such results, it is a scientifically valid and generally accepted methodology to estimate and/or model exposure levels based on relevant environmental data, which in this case, included (but was not limited to) the extensive data available regarding water lead levels, the presence of lead service lines, galvanized interior pipes, and lead-soldered copper plumbing, and other factors in Flint. It is also a scientifically valid and generally accepted methodology to model blood lead levels for individuals based on water lead levels, selected individual characteristics (such as age, sex, etc.) and the known pharmacokinetics of lead absorption, uptake, distribution, storage and elimination in humans. In providing my conclusions in this declaration, I have considered the materials referenced herein, as well as the expert declarations of Dr. Larry Russell, Dr. Clifford Weisel, Dr. Panos Georgopoulos, Dr. Pierre Goovaerts and Dr. Bruce Lanphear.

III. STATEMENT OF OPINION(S)

9. My opinions, and their scientific bases, are contained throughout this declaration. But summarized here are some of the most relevant considerations and opinions for purposes of presenting my analysis:

- (1) My opinion is predicated upon the work presented in the declarations of Drs. Russell, Weisel, Goovaerts, and Georgopoulos, which collectively present an integrated process of assessment of exposures and associated impacts. As set forth in those declarations, there are scientifically valid approaches towards using the data that are available to determine, with a reasonable degree of precision and accuracy, that each Flint child who is a member of the subclass confronted increased lead exposure as a result of the Flint Water Crisis.
- (2) For children, the scientific literature supports the view that (a) there is no known threshold of lead exposure below which such exposure is known to be safe; and (b) the greater the exposure to lead, the greater the adverse effects on health can be expected.
- (3) I have reviewed the subclass definition proposed by class counsel in this case. Each child who meets the criteria proposed in the subclass definition, and as further set forth herein, the criteria on which the definition is based, will more likely than not have experienced increased lead exposure as a result of the Flint water crisis. It is my opinion that the exposure is of a sufficient duration

and magnitude such that each child will have sustained non-negligible impairment of their neurobehavioral development.

This declaration addresses the following questions proposed by counsel:

- (1) Given the probable range of exposures presented in the Exposure Assessment Analysis, is it possible to identify a subclass of children (the “subclass of injured children”), each of whom were more likely than not to have suffered adverse impacts on health as a direct result of their exposure to Flint Water during the Flint Water Crisis period of May 1, 2014 to January 5, 2016”? This is referred to as the “Injury Question”;
- (2) If different scenarios of exposure are assumed for exemplar individual members of the “subclass of injured children”, what would be the associated individual adverse impacts on health?

The following paragraphs set out responses and recommendations, with the scientific rationale (facts or data considered) described in Section IV.

10. At the outset, it is critical to acknowledge that the requests noted above present several major challenges. One challenge is that “exposure” to water lead levels stemming from the Flint Water Crisis at the level of a typical residential tap can be expected to vary spatially (i.e. across locations within the city depending on the condition and type of service line, connectors, and

indoor plumbing at each location an individual consumes tap water or item prepared with tap water); temporally (i.e. over time - the course of a day, week, and month, because of flushing, water flow, local pipe and interior plumbing conditions); and frequency of an individual's consumption of the tap water. Another challenge is that even if an individual's level of exposure to tap water is known, that individual's internalized "dose" of lead, i.e., amount of lead that would be absorbed from the gastrointestinal tract into blood that, in turn, would serve as the dose of lead to target organs such as the brain, can be expected to vary based on that individual's nutritional status (e.g., low dietary iron or calcium, or fasting, can increase the amount of lead absorbed from the gastrointestinal tract) as well as biological factors (e.g., an individual's age [infants absorb more lead from the gastrointestinal tract than adults], genetics, etc). This latter challenge can be addressed by taking direct measurements of lead in blood ("blood lead levels") at different intervals. However, a blood lead level by itself cannot inform whether the lead came from absorption of lead from tap water vs. lead that had come from other sources (e.g., soil, paint, internal stores of lead in bone). Thus, to address the above questions in an ideal world, data would be available that could pinpoint, for each plaintiff, the exposures and resulting internal doses of lead that were a result of the Flint Water Crisis (such as, for each plaintiff, repeated measures

of lead in each plaintiff's tap water and venous blood taken before, during, and after the crisis, in conjunction with documentation on frequency of tap water consumption). This would provide data with which one could directly estimate an individual's exposure to lead in tap water and the influence of the lead so ingested on the individual's blood lead levels. By contrast, the exposure data that actually exist that are specific to individual plaintiffs are fragmentary, and in terms of time sequence, sporadic or only occurring at one point in time, and the internal dose data that actually exist that are specific to individual plaintiffs (i.e., blood lead levels) were not taken for most plaintiffs during time periods relevant to the Flint water crisis, or where available, are also sporadic or only occurring at one point in time.¹ Nevertheless, as described in: 1) the March 2016 report of the Flint Water Advisory Task Force appointed by the Governor of Michigan², 2) peer-reviewed academic literature which reviews lead exposure for Flint children in detail, and 3) the Exposure Assessment Analysis presented contemporaneously with this Declaration, there is no doubt that significant lead exposure occurred on a city-wide scale, given what is known about the changes in the Flint water supply, the resulting

¹ The paucity of data as it relates to the exposure of children to lead in water during the Flint Water Crisis may be at least partially explained by the actions of the Defendants, who, according to the Plaintiffs' Complaint, provided assurances to the community of Flint that the water was safe to drink.

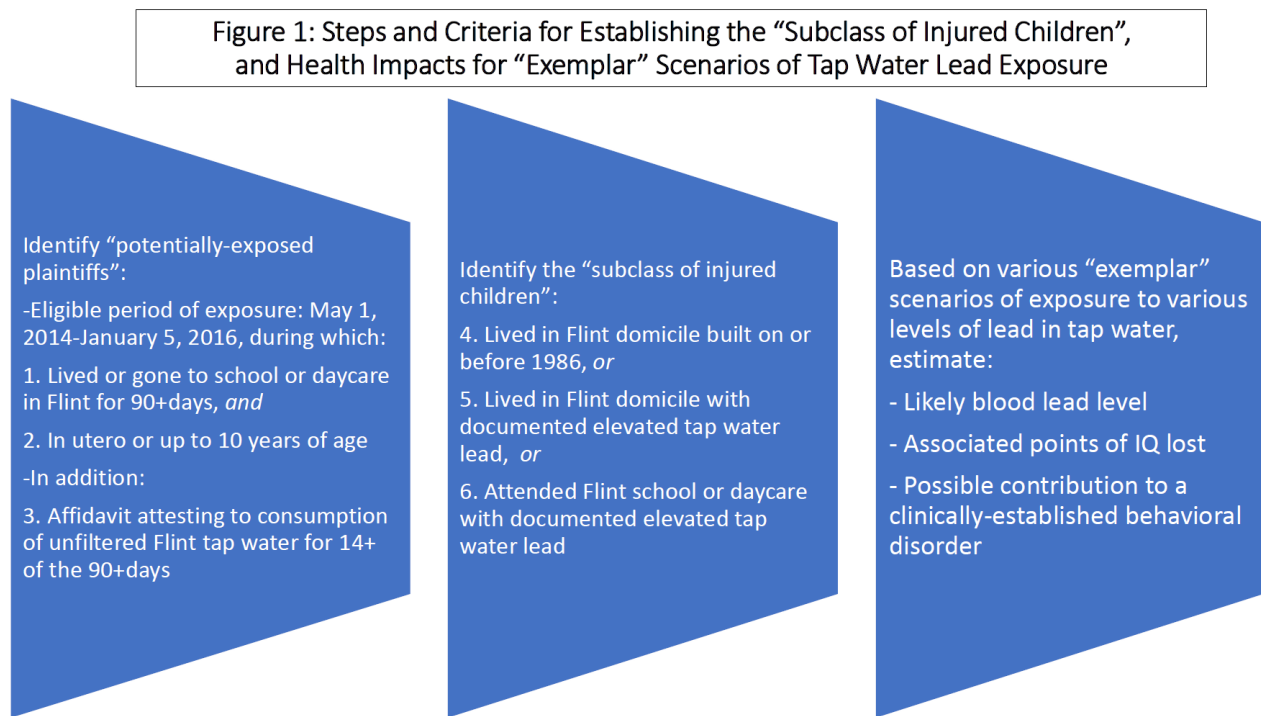
² Flint Water Advisory Task Force. *Final Report, Flint Water Advisory Task Force*. March, 2016. Office of Governor Rick Snyder, State of Michigan.

changes to the water chemistry, and the data (and analyses of that data) that are available.

11. In conjunction with the declarations of Drs. Russell, Weisel, Goovaerts, Georgopoulos, and Lanphear, this declaration thus describes a process of “assessment of exposures and associated impacts” to meet the task at hand. It begins by utilizing a scientifically valid approach to conducting an exposure reconstruction based on available information to determine who might have been exposed to a minimum amount of lead as a result of the Flint water crisis that could be expected to be associated with adverse impacts on health. It then uses publicly-available data and lead level data obtained in the discovery process to select several exemplar case studies at varying levels of tap water lead levels that have been associated with the Flint water crisis, and then uses a scientifically valid approach to estimate the associated blood lead levels of children in various age groups. It then provides estimates of the associated adverse impacts on health, focusing, in the case of children, on neurobehavioral developmental outcomes.

12. The task inherently requires a trans-disciplinary approach that integrates principles and methods related to water quality, chemistry, materials science; civil/environment engineering, exposure science, geostatistics, biological dosimetry, toxicokinetics, environmental

epidemiology, and general environmental health. Accordingly, what follows is the product of a trans-disciplinary team composed of experts who collectively provide overlapping expertise in each of the disciplines stated above (i.e., Dr. Larry Russell, Dr. Clifford Weisel, Dr. Panos Georgopoulos, Dr. Pierre Goovaerts, Dr. Lanphear and myself). A figure summarizing each step in the proposed approach is provided in Figure 1 and detailed below.



13. As a first step regarding a methodology for identifying a “subclass of injured children”, I point out that, in my opinion as an expert in the

environmental epidemiology of lead exposure and adverse health impacts (with a discussion of the associated scientific literature provided in Section IV and as acknowledged by the Michigan Department of Environmental Quality/EGLE), the scientific literature supports the view that (a) there is no known threshold of lead exposure below which such exposure is known to be safe; and (b) the greater the exposure to lead, the greater the adverse effects on health can be expected, i.e., the lead-adverse health effect relationship follows an incremental dose-incremental response relationship (monotonic sequence). As a result, the “subclass of injured children” could theoretically include all children who were likely to have been exposed to any lead as a direct result of the Flint Water Crisis. However, it is proposed that the “subclass of injured children” only include those children who were likely to have been exposed to lead as a direct result of the Flint Water Crisis over a period of at least 90 days as more fully set forth below. (the proposed criterion for the “eligible duration of exposure”). This helps to ensure that the “subclass of injured children” does not include individuals with trivial, fleeting, or unlikely lead exposure.

14. In terms of the “assessment of exposures and associated impacts”, having considered a number of sources of information (listed below) and having integrated the input and expertise of our trans-disciplinary team, the

definition of terms and the best scientific methodology, the following steps are proposed for identifying members of the “subclass of injured children”:

15. Consider the period of May 1, 2014 – January 5, 2016, as the “eligible period of exposure” of the Flint Water Crisis. This is acknowledged to differ from the April 25, 2014 – October 15, 2015 time period spanning when Flint water was initially switched from, and then switched back to its original source and method of treatment. The identification of May 1, 2014 as the beginning date of the “eligible period of exposure” is based on the expert input of Dr. Larry Russell and Dr. Clifford Weisel, which review aspects of water chemistry, the water distribution system in Flint, and other factors (see their Declarations). The assertion that the “eligible period of exposure” extended beyond October 15, 2015 date is based on (a) the recognition that there would be a substantial delay in re-establishing the stable “passivation” layer that protects against the leaching of lead into water in Flint’s water distribution system, as well as other factors (see expert declarations by Dr. Larry Russell and Dr. Clifford Weisel). Plaintiff’s counsel selected January 5, 2016 as the end date of the “eligible period of exposure”. That date coincides with Governor Snyder’s emergency declaration related to Flint. The rational and documentation for this are described in more detail in Section IV.

16. Identify as “potentially-exposed plaintiffs” all individuals who meet all 3 of the following definitions and criteria:

17. Criterion 1: Eligible location of exposure: Having lived (or been in-utero) or attended a school or day care in the city of Flint for at least 90 days during the “eligible period of exposure”.

18. Criterion 2: Eligible age range: Having been 0-10 years old in-utero (conception to birth) for at least 90 days (the “eligible duration of exposure”) in an “eligible location of exposure” during the “eligible period of exposure”.

19. Criterion 3: Eligible duration of exposure: To be eligible for inclusion in the subclass, the child (or their mother if *in utero*) must have drank or ate food prepared with unfiltered Flint tap water for at least 14 of the 90 days during the “eligible period of exposure”. This criterion will be met through an affidavit or sworn statement requirement from the child’s parent, guardian or caretaker.

20. I rely on the expert declarations provided by Dr. Larry Russell, Dr. Clifford Weisel, and Dr. Panos Georgopoulos for the basis for Criteria 1 and 3. The basis for Criterion 2 is provided in Section IV.

21. Among these “potentially exposed plaintiffs”, identify as members of the “subclass of injured children” those individuals who meet any one of the following criteria:

- i. Criterion 4: Having lived in a domicile in Flint that was built on or before 1986 when Section 1417 of the Safe Drinking Water Act was enacted. The basis for this is outlined in the declarations of Dr. Clifford Weisel and Dr. Larry Russell.
- ii. Criterion 5: Having lived in a domicile in Flint with confirmed documentation of lead in tap water lead subsequent to May 1, 2014 through January 5, 2016, or thereafter. This is defined as having a water lead value exceeding the minimum reporting limit of the method used. I rely on the expert report provided by Dr. Goovaerts for a compilation of parcels that had reported water lead levels³. To become a class member, an individual can also provide a reported water lead level from a certified monitoring laboratory, governmental agency, or a University Research laboratory which followed EPA guidelines for measuring water lead levels in a sample collected during the period specified above.

³ A database of 24,173 tap water lead samples, collected between 11/19/2014 and 10/13/2016, was assembled using several sources of publically available data described in the declaration of Dr. Pierre Goovaerts. Measurements collected after the end of the “eligible period of exposure” were used since, everything else being equal, water lead levels are expected to have declined since the end of the “eligible period of exposure” of the Flint Water Crisis. These data provide information for 34.88% of the 32,863 non-vacant residential and commercial tax parcels in the City of Flint. Whenever multiple samples were collected within the same tax parcel, the maximum water lead level was selected. Detectable levels of lead were found in 58.4% of non-vacant residential and commercial tax parcels that were sampled.

- iii. Criterion 6: Having attended a school or daycare supplied by Flint water that was known to have lead in the water. This is defined as having been found to have water lead levels greater than “Not detected” (i.e., >0 mg/L) in the testing of water in Flint community schools conducted on October 2, 2015⁴; or the “Pre-Fixture Replacement”, “Post-Fixture Replacement”, or “Post-Filter Installation” testing of water in Flint schools conducted in 2016⁵. It is defined as having been found to have water lead levels greater than 1 part per billion (1 ppb) or greater in the “Post-Fixture Replacement” testing of water conducted of Flint daycares in 2016⁶.
- iv. I note here that I relied on the expert declarations provided by Dr. Larry Russell, Dr. Clifford Weisel, and Dr. Pierre Goovaerts for the basis for the above criteria.
- v. In terms of process, I note that Dr. Goovaerts can construct a computerized “master” database that enables any individual to

⁴ Government of Michigan. *Flint Community Schools Initial Screening Results (Oct. 2, 2015)*. Available at https://www.michigan.gov/documents/deq/Flint_Community_Schools_Testing_Results_Initial_Screen_502382_7.pdf ; accessed on April 16, 2020.

⁵ Government of Michigan. *2016 Schools Testing Results*. Available at https://www.michigan.gov/flintwater/0,6092,7-345-76292_76294_76297_77897-455439--,00.html ; accessed on April 16, 2020.

⁶ Government of Michigan. *2016 Child/Day Care Testing Results*. Available at https://www.michigan.gov/flintwater/0,6092,7-345-76292_76294_76297_77898_77908---,00.html; accessed on May 23, 2020.

input his or her address, residential tax parcel number, or school, and determine if he or she meets any one of the above Criteria that determine eligibility for inclusion in the “subclass of injured children”.

vi. The criteria set forth above are encapsulated in the following proposed subclass definition:

The class is defined as children who, during the period from May 1, 2014 to January 5, 2016, were (a) in utero or between the ages of 0 to 10 years old, (b) lived in an identified residence or attended an identified school or day care, and (c) were exposed through ingestion to unfiltered Flint public water at such residence, school or day care for at least 14 days within a 90 day period.

As set forth above, “exposed through ingestion to unfiltered public water” means the child (or their mother) was exposed to unfiltered tap water for at least 14 days during a 90 day period between May 1, 2014 and January 5, 2016, through any combination of the following ways:

- (1) For childhood exposure: the child drank unfiltered Flint tap water (or beverages prepared with unfiltered tap water, including infant formula), and/or ate food prepared with unfiltered Flint tap water;

(2) For *in utero* exposure, the mother drank unfiltered Flint tap water (or beverages prepared with unfiltered tap water), and/or ate food prepared with unfiltered Flint tap water, while pregnant.

22. In the paragraphs above, I have thus responded to the first question posed at the outset by laying out a set of criteria and a process for identifying a subclass of children, each of whom, in my opinion, more likely than not suffered adverse impacts on health as a direct result of their exposure to Flint Water during the Flint Water Crisis period of May 1, 2014 to January 5, 2016 (i.e., the “Injury Question”). Specifically, children who meet these minimum criteria are expected to have experienced lead exposure as a result of the Flint water crisis of a sufficient duration and magnitude to have sustained non-negligible impairment of their neurobehavioral development.

As noted at the outset, the second question is: If different scenarios of exposure are assumed for exemplar individual members of the “subclass of injured children”, what would be the associated individual adverse impacts on health? Accomplishing this task requires 3 separate steps:

- a. First, I rely on input from Dr. Clifford Weisel and Dr. Pierre Goovaerts to describe the range of water lead levels that have been experienced among Flint residents during the Flint water crisis, and to

select various levels of tap water lead across this range as exemplars of exposure scenarios.

b. Next, to extrapolate the likely blood lead levels that would result in relation to these different exposure scenarios of levels of lead contamination in tap water, I rely on the application by Dr. Panos Georgopoulos of (a) EPA's Integrated Exposure and Uptake Biokinetic (IEUBK) model for children from 0 to 7 years of age; and (b) an alternative model proposed by Dr. Georgopoulos for adult women from 20 to 25 years old (to provide estimates of in-utero exposures, since lead is known to freely cross the placenta) (see declaration by Dr. Panos Georgopoulos). These extrapolations include the likely "baseline blood lead levels", i.e., the blood lead levels for children of different age groups that would result if the water lead level is below the detectable limit (i.e., indistinguishable from 0). It is noted here that the associated blood lead levels are not necessarily 0, since there are also assumed levels of exposure from other sources, such as dust and soil. The estimated "baseline blood lead level" can then be subtracted from the estimated blood lead levels associated with a given tap water lead level to calculate the estimated

blood lead level specific for the contribution of the Flint water crisis, i.e., the “Flint water crisis-associated elevation in blood lead level”.

c. Finally, for each of several exemplar cases, I use the estimates of “Flint water crisis-associated elevation in blood lead level” to estimate the associated impacts on decrements in IQ. For this calculation, I use the dose-response estimation of 0.51 points of IQ lost per 1 µg/dL elevation in blood lead generated by Lanphear et al. (2005⁷, 2019⁸).

In my opinion, such an impact more likely than not is causal. In addition, it is my opinion that it is reasonable to apply the same dose-response relationship associated with children exposed from age 4-10 years old (the age range associated with the blood lead-IQ relationships studied by Lanphear et al.) to children exposed in -utero as well as from 0 to 4 years of age.

⁷ Lanphear BP, Hornung R, Khoury J, Yolton K, Baghurst P, Bellinger DC, Canfield RL, Dietrich KN, Bornschein R, Greene T, Rothenberg SJ, Needleman HL, Schnaas L, Wasserman G, Graziano J, Roberts R. Low-level environmental lead exposure and children's intellectual function: an international pooled analysis. *Environ Health Perspect.* 2005 Jul;113(7):894-9. doi: 10.1289/ehp.7688. Erratum in: *Environ Health Perspect.* 2019 Sep;127(9):99001. PMID: 16002379; PMCID: PMC1257652.

⁸ Lanphear BP, Hornung R, Khoury J, Yolton K, Baghurst P, Bellinger DC, Canfield RL, Dietrich KN, Bornschein R, Greene T, Rothenberg SJ, Needleman HL, Schnaas L, Wasserman G, Graziano J, Roberts R. Erratum: "Low-Level Environmental Lead Exposure and Children's Intellectual Function: An International Pooled Analysis". *Environ Health Perspect.* 2019 Sep;127(9):99001. doi: 10.1289/EHP5685. Epub 2019 Sep 17. Erratum for: *Environ Health Perspect.* 2005 Jul;113(7):894-9. PMID: 31526192; PMCID: PMC6792371.

Table 1

BLL estimates ($\mu\text{g/dL}$) from IEUBK (for ages up to 7 years) and from AALM-Leggett (for 90 days exposure of 20,23,25 years-old female subjects) for representative WLLs ($\mu\text{g/L}$)

		BLL (µg/dL)										
		Age (years)										
	WLL (µg/L)	WLL increase (µg/L) over pre-crisis level	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	20	23	25
Pre-Crisis Levels	1.00		1.85	1.97	1.81	1.70	1.40	1.19	1.07	1.71	2.10	2.27
	2.00	1.00	1.90	2.06	1.90	1.79	1.49	1.28	1.15	1.77	2.16	2.37
	3.00	2.00	1.95	2.15	1.99	1.87	1.57	1.36	1.23	1.80	2.20	2.41
	5.00	4.00	2.05	2.32	2.16	2.04	1.74	1.53	1.39	1.84	2.26	2.49
	10.00	9.00	2.30	2.76	2.60	2.47	2.17	1.95	1.79	1.95	2.42	2.69
	20.00	19.00	2.78	3.60	3.45	3.30	2.99	2.76	2.57	2.18	2.74	3.09
	50.00	49.00	4.16	5.95	5.82	5.62	5.31	5.07	4.77	2.85	3.71	4.30
	100.00	99.00	6.27	9.35	9.27	9.04	8.76	8.51	8.08	3.98	5.33	6.30
	200.00	199.00	9.88	14.82	14.85	14.64	14.48	14.26	13.66	6.24	8.54	10.12
	300.00	299.00	12.92	19.18	19.29	19.16	19.13	18.97	18.26	8.48	11.36	13.48

In Table 1, Dr. Panos Georgopoulos has provided a matrix of water lead levels and associated blood lead levels. The water lead levels span the levels of lead observed in Flint water during the Flint water crisis, with references citing the sources of the data (see declaration by Dr. Georgopoulos). The blood lead levels were calculated by Dr. Georgopoulos based on the water lead levels and application of the U.S. Environmental Protection Agency's Integrated Environmental Uptake and Biokinetic (IEUBK) model for children 0 to 7 years old, and on application of a specific model recommended by Dr. Georgopoulos for adult women 20 to 25 years old. In my opinion, it is

reasonable to assume that the blood lead levels of the adult women approximate the lead levels that would be seen in umbilical cord blood samples if the women were pregnant and had given birth. From this matrix, I have then highlighted (in red circles) four “exemplars” with which to illustrate impacts of the Flint water crisis, i.e. children 1-2, 3-4, and 6-7 years old with water lead levels of 200, 20, and 2 $\mu\text{g/L}$, respectively; and a 23 year old mother with a water lead level of 5 $\mu\text{g/L}$. For each of these individuals, the blood lead level attributable to the Flint water crisis can be calculated by subtracting the “baseline” blood lead level (i.e. the first row in the table, which represents the likely blood lead level before the Flint water crisis) from the modeled blood lead level associated with a given water lead level. For the 1-2, 3-4, and 6-7 year old children and the 23 year old mother consuming water at levels of 200, 20, 2 and 5 $\mu\text{g/L}$, respectively, the blood lead levels attributable to the Flint water crisis are calculated to be 12.85, 1.6, 0.08, and 0.15 $\mu\text{g/dL}$.⁹

Applying the effect estimates generated by Lanphear et al. (2019) of 0.51 points of IQ lost for every 1 $\mu\text{g/dL}$ increase in blood lead, the afore-mentioned

⁹ As a cross-comparison, I note that in their geospatial analysis of measured blood lead levels, Hanna-Attisha et al. (2016⁹) estimated that children living in Flint’s Ward 5 had a mean elevation in blood lead attributable to the Flint water crisis of 0.51 $\mu\text{g/dL}$. In Table 1, this would fall within the range of estimated increased blood leads associated with drinking water contaminated with 10 $\mu\text{g/L}$ lead in a 0.5-1 year old infant (0.45 $\mu\text{g/dL}$) and a 4-5 year old child (0.77 $\mu\text{g/dL}$). Hanna-Attisha M, LaChance J, Sadler RC, Champney Schnepf A. Elevated Blood Lead Levels in Children Associated With the Flint Drinking Water Crisis: A Spatial Analysis of Risk and Public Health Response. *Am J Public Health*. 2016 Feb;106(2):283-90. doi: 10.2105/AJPH.2015.303003. Epub 2015 Dec 21. PMID: 26691115; PMCID: PMC4985856.

exemplar cases of individuals with elevations in blood lead can be seen to be associated with decrements in IQ of 6.6, 0.82, 0.04, and 0.08 points of IQ. I note that although some critics have questioned the importance of small decrements in the IQs of individual children¹⁰, as noted by Rogan and Ware in an editorial in the New England Journal of Medicine: “...these measures (IQ) are blunt instruments for detecting subtle changes in brain function; any detectable effect occurring from a widespread exposure is cause for concern. Relatively small changes in the mean IQ of a large number of children will dramatically increase the proportion of the population below any fixed level of concern such as an IQ of 80 and decrease the proportion above any ‘gifted’ level, such as 120.”¹¹ In addition, it is noted that the estimated decrements in IQ are calculated in relation to exposure to lead, the measurement of which is typically estimated using a single blood lead level at one point of time (or, at most, two or three blood lead levels spaced months to years apart). Given that actual lead exposures for most individuals likely fluctuate over time, these few blood lead levels likely estimate “true” lead exposure with random (AKA “classical”) error. Random error, in turn, is well known to bias estimates of

¹⁰ Kaufman AS. Do low levels of lead produce IQ loss in children? A careful examination of the literature. Arch Clin Neuropsychol. 2001 May;16(4):303-41. PMID: 14590165.

¹¹ Rogan WJ, Ware JH. Exposure to lead in children--how low is low enough? N Engl J Med. 2003 Apr 17;348(16):1515-6. doi: 10.1056/NEJMp030025. PMID: 12700370.

effect towards the null¹² (i.e., towards seeing a diminished effect, or none at all). Thus, the “true” blood lead-IQ relationship, i.e., the estimate of the magnitude of the effect if the blood lead level that best summarized an individual’s lead exposure throughout childhood were known, is likely higher than what has been estimated by Lanphear et al. (2015). Finally, an opinion could theoretically be rendered regarding impacts of “Flint water crisis-associated elevation in blood lead levels” on an individual’s diagnosis of a neurobehavioral disorder. This would depend on the specific diagnosis that is established as well as the timing of onset or worsening of the condition in relation to the individual’s period of exposure.

IV. FACTS OR DATA CONSIDERED

23. As noted in paragraph 14, the scientific literature supports the view that (a) there is no known threshold of lead exposure below which such exposure is known to be safe; and (b) the greater the exposure to lead, the greater the adverse effects on health can be expected, i.e., the lead-adverse health effect relationship follows an incremental dose-incremental response relationship (monotonic sequence). The evidence supporting (a) and (b) includes specific

¹² Sheppard L, Burnett RT, Szpiro AA, Kim SY, Jerrett M, Pope CA 3rd, Brunekreef B. Confounding and exposure measurement error in air pollution epidemiology. *Air Qual Atmos Health*. 2012 Jun;5(2):203-216. doi: 10.1007/s11869-011-0140-9. Epub 2011 Mar 23. PMID: 22662023; PMCID: PMC3353104.

analyses¹³, meta-analyses¹⁴, and reviews¹⁵ of epidemiologic studies relating blood lead levels, going down to a level of 1 µg/dL, with decrements in IQ in children. In addition, in terms of governmental review, the 22 members of the U.S. Centers for Disease Control and Prevention's Advisory Committee on Childhood Lead Poisoning Prevention and its Blood lead Level Work Group concluded that "Because no measurable level of blood lead is known to be without deleterious effects, and because once engendered, the effects appear to be irreversible in the absence of any other interventions, public health, environmental and housing policies should encourage prevention of all exposures to lead¹⁶." In its June 2012 systematic review of the health effects of low-level lead exposure, the U.S. National Toxicology Program

¹³ Such as: (a) Schnaas L, Rothenberg SJ, Flores MF, Martinez S, Hernandez C, Osorio E, Velasco SR, Perroni E. Reduced intellectual development in children with prenatal lead exposure. *Environ Health Perspect.* 2006 May;114(5):791-7. PubMed PMID: 16675439; PubMed Central PMCID: PMC1459938; (b) Chiodo LM, Covington C, Sokol RJ, Hannigan JH, Jannise J, Ager J, Greenwald M, Delaney-Black V. Blood lead levels and specific attention effects in young children. *Neurotoxicol Teratol.* 2007 Sep-Oct;29(5):538-46. Epub 2007 Apr 21. PubMed PMID: 17553667; (c) Searle AK, Baghurst PA, van Hooff M, Sawyer MG, Sim MR, Galletly C, Clark LS, McFarlane AC. Tracing the long-term legacy of childhood lead exposure: a review of three decades of the port Pirie cohort study. *Neurotoxicology.* 2014 Jul;43:46-56. doi: 10.1016/j.neuro.2014.04.004. Epub 2014 Apr 28. PubMed PMID: 24785378.

¹⁴ Such as: (a) Schwartz J. Low-level lead exposure and children's IQ: a meta-analysis and search for a threshold. *Environ Res.* 1994 Apr;65(1):42-55. PubMed PMID: 8162884; and (b) Budtz-Jørgensen E, Bellinger D, Lanphear B, Grandjean P; International Pooled Lead Study Investigators. An international pooled analysis for obtaining a benchmark dose for environmental lead exposure in children. *Risk Anal.* 2013 Mar;33(3):450-61. doi: 10.1111/j.1539-6924.2012.01882.x. Epub 2012 Aug 24. PubMed PMID: 22924487.

¹⁵ Such as: (a) Jakubowski M. Low-level environmental lead exposure and intellectual impairment in children--the current concepts of risk assessment. *Int J Occup Med Environ Health.* 2011 Mar;24(1):1-7. doi: 10.2478/s13382-011-0009-z. Epub 2011 Feb 16. Review. PubMed PMID: 21468897; and (b) Carlisle JC, Dowling KC, Siegel DM, Alexeeff GV. A blood lead benchmark for assessing risks from childhood lead exposure. *J Environ Sci Health A Tox Hazard Subst Environ Eng.* 2009 Oct;44(12):1200-8. doi: 10.1080/10934520903139829. Review. PubMed PMID: 19847706.

¹⁶ ACCLPP, 2012. *Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention.* Report of the Advisory Committee on Childhood Lead Poisoning Prevention of the Centers for Disease Control and Prevention. January 4, 2012.

concluded that “In children, there is sufficient evidence that blood Pb levels <5 µg/dL are associated with decreases in broad based and specific indices of cognitive function and an increase in attention-related behavioral problems and antisocial behavioral problems.”¹⁷ In its 2013 Scientific Opinion on Lead in Food, the Panel on Contaminants in the Food Chain Panel of the European Food Safety Authority identified developmental neurotoxicity in young children as one of the critical effects for its risk assessment. As such, the Panel concluded that “... the current PTWI [provisional tolerable weekly intake] of 25 µg/kg body weight is no longer appropriate as there is no evidence for a threshold for critical lead-induced effects.”¹⁸ The State of Michigan acknowledges that “no level of lead in the blood is safe.”¹⁹

24. As noted in paragraph 15.a, the period of May 1, 2014 – January 5, 2016, is proposed as the designated “eligible period of exposure” of the Flint Water Crisis (this is acknowledged to differ from the April 25, 2014 – October 15, 2015 time period spanning when Flint water was initially switched from, and then switched back to its original source and method of treatment). The

¹⁷ NTP Monograph. *Health Effects of Low-Level Lead*. US Department of Health and Human Services, National Toxicology Program. June 2012. Available at: https://ntp.niehs.nih.gov/ntp/ohat/lead/final/monographhealtheffectslowlevellead_newissn_508.pdf ; accessed on April 13, 2020.

¹⁸ EFSA. *Scientific Opinion on Lead in Food*. European Food Safety Authority Panel on Contaminants in the Food Chain (CONTAM). Updated on March 22, 2013; available at: <https://www.efsa.europa.eu/en/efsajournal/pub/1570> ; accessed on April 13, 2020.

¹⁹ https://www.michigan.gov/documents/egle/tou-LCRWorkshopPresentation-OverviewRevisions_656454_7.pdf, p.6.

evidence supporting May 1, 2014 as the designated start of the eligible period of exposure is discussed in the expert declarations provided by Dr. Larry Russell and Dr. Clifford Weisel, which review aspects of water chemistry, the water distribution system in Flint, and other factors. Extension of the exposure period beyond the October 16, 2015 date (the date Flint reconnected to Detroit water) is based on (a) the recognition that there would be a substantial delay in re-establishing the stable “passivation” layer that protects against the leaching of lead into water in Flint’s water distribution system, as well as other factors (see expert declarations by Dr. Larry Russell and Dr. Clifford Weisel). The proposed eligibility period end date of January 5, 2016, coincides with the day that Governor Rick Snyder issued his emergency declaration²⁰. .

25. As noted in paragraph 15.b.i. (Criterion 1), having lived (or been in-utero) or attended a school or daycare in the city of Flint for at least 90 days during the “eligible period of exposure” is proposed as the “eligible location of exposure”. The 90 day requirement helps to ensure that the “subclass of injured children” does not include individuals with trivial, fleeting, or unlikely lead exposure. It also makes it possible, within the “subclass of injured

²⁰ Snyder R. *Proclamation: Declaration of Emergency*. January 5, 2016, 4:00pm. State of Michigan, Executive Office.

children”, to use established scientific approaches, such as the U.S. Environmental Protection Agency’s Integrated Exposure Uptake Biokinetic (IEUBK) model, which is based on exposure over a minimum period of 90 days, to translate levels of lead in water (the lead “exposure”) to levels of lead in blood (the internalized lead “dose). Further discussion of this rationale is provided in the expert Declaration of Dr. Panos Georgopoulos.

26. As noted in paragraph 15.b.ii. (“Criterion 2”), having been 0-10 years old or in-utero (conception to birth) for at least 90 days (the “eligible duration of exposure”) in an “eligible location of exposure” during the “eligible period of exposure” is proposed as the “eligible age range”. This age range is chosen because it is very clear from the scientific literature that lead is toxic to neurodevelopment and has other adverse consequences when exposure occurs during the prenatal period²¹ as well as during childhood²²; in addition the age range of the children included in the 7 international pooled studies analyzed by Lanphear et al. (2005) and that provided the best source of guidance on the dose-response relationship between blood lead levels and IQ loss ranged from 4 to 10 years of age.

²¹ Centers for Disease Control and Prevention (CDC). Work Group on Lead and Pregnancy. Ettinger AS and Wengrowitz AG, Editors. *Guidelines for the Identification and Management of Lead Exposure in Pregnant and Lactating Women*. Atlanta: Centers for Disease Control. November, 2010. Available at: <https://www.cdc.gov/nceh/lead/prevention/pregnant.htm> ; accessed May 20, 2020

²² ACCLLP, 2012, *ibid.*; NTP, 2012, *ibid.*

27. The evidence for specifying “unfiltered Flint tap water” in paragraph 15.b.iii (Criterion 3) is provided in the declaration by Dr. Clifford

28. The evidence for paragraph 15.c.i. (Criterion 4) is provided in the Declarations of Dr. Clifford Weisel and Dr. Larry Russel.

29. The evidence for paragraph 15.c.ii. (Criterion 5) is provided in the Declarations of Drs. Larry Russell, Pierre Goovaerts, and Clifford Weisel.

30. The evidence for paragraph 15.c.iii. (Criterion 6) is provided in the documents that can be accessed on the State of Michigan website as noted in the associated footnotes.

31. The evidence for paragraph 17.a., that is, the range of water lead levels experienced among Flint residents during the Flint water crisis, is described in the expert declarations of Dr. Clifford Weisel and Pierre Goovaerts.

32. The evidence for paragraph 17.b., that is, the approach for estimating likely elevations in blood lead levels as a result of various exposure scenarios of level of lead contamination in tap water across different age groups of children is described in the expert declaration of Dr. Panos Georgopoulos.

33. The evidence for paragraph 17.c., that is, the recommendation and methodology for expressing the impact of lead exposure on health in terms of IQ for the several exemplar cases, is as follows:

- a. I recommend focusing on IQ since there is a robust literature on the economic consequences of points of IQ lost as well as the need for special education services.
- b. With regards to estimating the points of IQ lost for an individual Flint child who had experienced exposure to the elevated lead in Flint water, there are several issues that make it impossible to make such estimates by simply measuring the IQ of an individual Flint child: (a) any one child is unlikely to have had “baseline”, i.e., pre-exposure IQ testing with which one could then conduct post-exposure IQ testing and deduce change in IQ; (b) even if such pre- and post-testing were available, if the magnitude of lead exposure and resulting impact on IQ is modest, such pre- and post-testing may not be able to reliably distinguish “true” changes in IQ from the random “noise” that typically occurs when IQ tests are repeated in the same individual (random measurement error); (c) scientific evidence indicates that the adverse impact of lead exposure on intelligence can be expected to occur regardless of whether an individual has a low, medium (i.e., average), or high IQ. Thus, for example, the effect of lead exposure on an individual who might otherwise have had a high IQ could be expected to result in that individual’s IQ decreasing into

the average range. Such an effect cannot be accurately and precisely determined directly by assessing an individual based on a single IQ test.

- c. In my opinion, determination of what an individual child's IQ decrement attributable to the Flint Water Crisis is best determined by extrapolating from population-based data the expected loss of IQ points based on the degree of lead exposure as quantified by each individual's blood lead level. In other words, it is preferable, in my opinion, to rely on the quantitative dose-response relationships between blood lead levels and child IQ that have been generated by rigorous population-based epidemiologic research.
- d. Through the execution of rigorously standardized research protocols for measuring blood lead levels, IQ (and other cognitive outcomes), and covariates (i.e., potential confounders, such as maternal age, maternal education, maternal IQ, marital status, child's sex, birth weight, birth order, prenatal smoking status, prenatal alcohol use), and then carefully conducting multivariate analyses that are able to focus on the relationship of blood lead levels and IQ that is independent of the covariate/potential confounders, this kind of research offers the best available data for estimating points of IQ lost associated with specific levels of lead in blood. In particular, I recommend the "International Pooled Analysis"

of blood lead levels and IQ conducted by Lanphear et al. (2005), which examined, pooled, and analyzed data that had been collected from 1,333 children who participated in seven rigorous international population-based longitudinal cohort studies, followed from birth or infancy until 5–10 years of age. The US EPA has relied on the analyses conducted by Lanphear et al. (2005) for its risk assessment of lead exposure²³ and I and others view this study as “the most complete and compelling evidence” of the quantitative nature and shape of the relationship between children’s blood lead levels and intelligence. This study found that of several blood lead level metrics measured (concurrent, peak, early childhood, lifetime average), blood lead levels taken concurrently with the IQ tests (which were measured between 4 years, 10 months and 7 years of age) were the most predictive of IQ score. In subsequent analyses using this metric (concurrent blood lead level), the analysis that is most relevant to the current subject is the one of children with blood lead levels less than 7.5 µg/dL. This is because even though studies have demonstrated that the switch of Flint’s water supply from Detroit to Flint

²³ US EPA. *Lead: Human Exposure and Health Risk Assessments for Selected Case Studies. Volume I. Human Exposure and Health Risk Assessments – Full-scale.* October, 2007, page 2-10. Research Triangle Park, North Carolina: US Environmental Protection Agency, Office of Air Quality Planning and Standards.

was associated with a general increase in blood lead levels^{24, 25}, overall, the majority of children's blood lead levels (95% or greater) remained less than 5 µg/dL before, during, and after the Flint water crisis. Regarding children with blood lead levels less than 7.5 µg/dL, Lanphear found that an increase in blood lead levels from 2.5 to 7.5 µg/dL was associated with a loss of 2.53 IQ points²⁶. Assuming a linear dose-response relationship in the interval of 2.5 to 7.5 µg/dL (an assumption that is aligned with the piece-wise linear approach, which gives the best-fitting models of the relationship between blood lead levels and IQ²⁷), an increase in blood lead of 1 µg/dL could therefore be expected to be associated with a $2.53/5.0=0.51$ points of IQ loss. In my opinion, it is thus reasonable to assume this quantitative relationship between blood

²⁴ Hanna-Attisha M, LaChance J, Sadler RC, Champney Schnepf A. Elevated Blood Lead Levels in Children Associated With the Flint Drinking Water Crisis: A Spatial Analysis of Risk and Public Health Response. *Am J Public Health*. 2016 Feb;106(2):283-90. doi: 10.2105/AJPH.2015.303003. Epub 2015 Dec 21. PubMed PMID: 26691115; PubMed Central PMCID: PMC4985856

²⁵ Kennedy C, Yard E, Dignam T, Buchanan S, Condon S, Brown MJ, Raymond J, Rogers HS, Sarisky J, de Castro R, Arias I, Breyse P. Blood Lead Levels Among Children Aged <6 Years - Flint, Michigan, 2013-2016. *MMWR Morb Mortal Wkly Rep*. 2016 Jul 1;65(25):650-4. doi: 10.15585/mmwr.mm6525e1. PubMed PMID: 27359350.

²⁶ The authors originally calculated an associated loss of 2.94 IQ points. They subsequently published a correction and found the applicable IQ decrement to be 2.53 points of IQ. Lanphear BP, Hornung R, Khoury J, Yolton K, Baghurst P, Bellinger DC, Canfield RL, Dietrich KN, Bornschein R, Greene T, Rothenberg SJ, Needleman HL, Schnaas L, Wasserman G, Graziano J, Roberts R. Erratum: "Low-Level Environmental Lead Exposure and Children's Intellectual Function: An International Pooled Analysis". *Environ Health Perspect*. 2019 Sep;127(9):99001. doi: 10.1289/EHP5685.

²⁷ Budtz-Jørgensen E, Bellinger D, Lanphear B, Grandjean P; International Pooled Lead Study Investigators. An international pooled analysis for obtaining a benchmark dose for environmental lead exposure in children. *Risk Anal*. 2013 Mar;33(3):450-61. doi: 10.1111/j.1539-6924.2012.01882.x. Epub 2012 Aug 24. PubMed PMID: 22924487.

lead level and points of IQ loss for children 5-10 years old, given that this is the age range studied by Lanphear et al. (2005, 2019).

- e. The estimate of the IQ decrement effect averages across the population affected. Practically-speaking, it means that, given an example of a child with an estimated elevation in blood lead from the Flint water crisis of 1 $\mu\text{g/dL}$, although the mean “expected” loss of IQ points projected by Lanphear et al. (2005, 2019) is 0.51 points of IQ, there may be some children who would lose only 0.31 point of IQ, yet other who lose 0.71 points of IQ, based on inter-individual variations in susceptibility. The statistical procedures used by Lanphear et al. essentially integrate across the spectrum of children to produce an estimate of the “average” points of IQ lost per unit increase in blood lead level.
- f. The evidence for the opinion that it is reasonable to assume that the quantitative relationship between blood lead level and points of IQ loss described above for children 4-10 years old (0.51 points of IQ for every 1 $\mu\text{g/dL}$ increase in blood lead) will apply to children exposed between the ages of 0-4 years and children exposed in-utero, is grounded in the available most rigorous studies of the blood lead level-IQ relationship at these particular stages of life.

g. With regards to the age range of 0-4 years, in the Lanphear et al. (2005) analyses, a separate analysis of the relationship of blood lead levels in early childhood (defined as 6 months to 24 months of age) and declines in IQ was not reported for individuals with blood lead levels less than 7.5 $\mu\text{g/dL}$. Nevertheless, the impacts of blood lead levels in early childhood (6 months to 24 months) v. concurrent blood lead levels (4 to 10 years of age) were compared for the full set of individuals. This demonstrated that the estimates of the magnitude of the adverse effect on IQ of blood lead levels in early childhood v. concurrent blood lead levels were similar (within 17%)²⁸. The research conducted by my own team also generated effect estimates of the impact of blood lead levels at 2 years of age on measures of intelligence measured at 4 years of age that were similar in magnitude as that reported by Lanphear et al. for concurrent blood lead levels (age 4-10 years). In our study, of which the median blood lead level in our children at 2 years of age was 4.6 $\mu\text{g/dL}$, a 1 $\mu\text{g/dL}$ increase in blood lead at 2 years of age was associated with a decrease in General

²⁸ Mean adjusted changes in full-scale IQ score associated with an increase in blood lead concentration (log scale), from the 5th to 95th percentile of the concurrent blood lead level at the time of IQ testing, comparing early childhood blood lead levels v. concurrent blood lead levels: -2.21 (95% confidence interval, -3.38 to -1.04) v. -2.65 (95% confidence interval: -3.69 to -1.61), respectively. Table 4, Lanphear BP, Hornung R, Khoury J, Yolton K, Baghurst P, Bellinger DC, Canfield RL, Dietrich KN, Bornschein R, Greene T, Rothenberg SJ, Needleman HL, Schnaas L, Wasserman G, Graziano J, Roberts R. Erratum: "Low-Level Environmental Lead Exposure and Children's Intellectual Function: An International Pooled Analysis". Environ Health Perspect. 2019 Sep;127(9):99001. doi: 10.1289/EHP5685.

Cognitive Index scores on the McCarthy Scales of Children's Abilities (a general measure of IQ at age 4) of from 0.54 to 0.65 points²⁹, which is higher than the 0.51 points of IQ per 1 µg/dL increase in blood lead level proposed in this declaration. Thus, in my opinion, the assumption of a 0.51 points of IQ decline per 1 µg/dL increase in blood lead level for children 0-4 years of age is reasonable.

- h. With regards to children exposed in-utero, an expert Committee convened by the U.S. Centers for Disease Control and Prevention (of which I was a member) concluded in 2010³⁰ that "A large number of studies provide convincing evidence that prenatal lead exposure impairs children's neurodevelopment...". Although the U.S. National Toxicology Program's review of the literature concluded that the evidence for prenatal lead exposure's adverse impact on measures of offspring cognitive function at low blood lead levels (less than 5 µg/dL) existed but was "limited", in my opinion, the evidence more likely than not indicates an adverse effect. However, the literature that can provide

²⁹ Table 3, adjusted change in 4 year General Cognitive Index score with a 10 ug/dL increase in child blood lead concentrations, focusing on the 2 year old child blood lead level, and extrapolating from 10 to 1 ug/dL. Braun JM, Hoffman E, Schwartz J, Sanchez B, Schnaas L, Mercado-Garcia A, Solano-Gonzalez M, Bellinger DC, Lanphear BP, Hu H, Tellez-Rojo MM, Wright RO, Hernandez-Avila M. Assessing windows of susceptibility to lead-induced cognitive deficits in Mexican children. *Neurotoxicology*. 2012 Oct;33(5):1040-7. doi: 10.1016/j.neuro.2012.04.022. Epub 2012 May 10. PMID: 22579785; PMCID: PMC3576696.

³⁰ Centers for Disease Control and Prevention (CDC). Work Group on Lead and Pregnancy. Ettinger AS and Wengrowitz AG, Editors. *Guidelines for the Identification and Management of Lead Exposure in Pregnant and Lactating Women*. Atlanta: Centers for Disease Control. November, 2010. Available at: <https://www.cdc.gov/nceh/lead/prevention/pregnant.htm> ; accessed May 20, 2020

specific quantitative estimates of the impact of prenatal lead exposure on off-spring IQ in the course of rigorously-conducted research and focusing on blood lead levels below 10 µg/dL is somewhat limited and inconsistent. Overall, the quantitative estimates of the effect have varied over a fairly wide range, with, for example, one recent study³¹ among children whose mothers during pregnancy had blood lead levels ranging from 0.14 to 4.14 µg/dL showing a profound effect on boys (with a 1 µg/dL increase in umbilical cord blood lead associated with a 2.65 point decline in IQ) but not on girls; another showing a 4 to 7 point decrement in the IQs of boys and girls age 4-7 years associated with a one unit increase in the natural log of maternal blood lead levels during pregnancy among mothers whose pregnancy-associated blood lead levels were around 5 µg/dL³²; another showing a 4.13 point decrement in the IQs of boys and girls 6-10 years of age associated with a one unit natural log increase in maternal blood lead levels at 28 weeks of pregnancy³³ among mothers who had 28 week pregnancy blood lead levels with a geometric

³¹ Table 4, Effect modification by gender. Desrochers-Couture M, Oulhote Y, Arbuckle TE, Fraser WD, Séguin JR, Ouellet E, Forget-Dubois N, Ayotte P, Boivin M, Lanphear BP, Muckle G. Prenatal, concurrent, and sex-specific associations between blood lead concentrations and IQ in preschool Canadian children. *Environ Int.* 2018 Dec;121(Pt 2):1235-1242. doi: 10.1016/j.envint.2018.10.043. Epub 2018 Nov 2. PubMed PMID: 30392942.

³² Wasserman GA, Liu X, Popovac D, Factor-Litvak P, Kline J, Waternaux C, LoIacono N, Graziano JH. The Yugoslavia Prospective Lead Study: contributions of prenatal and postnatal lead exposure to early intelligence. *Neurotoxicol Teratol.* 2000 Nov-Dec;22(6):811-8. PubMed PMID: 11120386.

³³ Schnaas L, Rothenberg SJ, Flores MF, Martinez S, Hernandez C, Osorio E, Velasco SR, Perroni E. Reduced intellectual development in children with prenatal lead exposure. *Environ Health Perspect.* 2006 May;114(5):791-7. PubMed PMID: 16675439; PubMed Central PMCID: PMC1459938.

mean of 7.8 $\mu\text{g/dL}$; and another showing weak (in boys) or no (in girls) adverse impacts of prenatal blood lead levels on the IQ of children at 4 and 8 years of age among mothers with a median blood lead level during pregnancy of 3.7 $\mu\text{g/dL}$ ³⁴. Overall, in my opinion, the inconsistency of results is a reflection of the relative paucity of rigorous studies on this topic (rather than an indication of a weak effect of prenatal lead exposure). Given that most lines of toxicological evidence indicate that the developing fetal nervous system is particularly vulnerable to the toxicity of lead^{35, 36}, in my opinion, it is reasonable to assume that the quantitative estimate of effect for the impact of prenatal lead exposure (as reflected by maternal blood lead levels during pregnancy) is the same as the quantitative estimate of effect for the impact of postnatal (i.e., children's) blood lead levels on their IQ's, i.e., 0.51 points of IQ per 1 $\mu\text{g/dL}$ elevation in blood lead.

34. Finally, Paragraph 18, sets forth that for children who are members of the “subclass of injured children”, an opinion could be rendered regarding

³⁴ Taylor CM, Kordas K, Golding J, Emond AM. Effects of low-level prenatal lead exposure on child IQ at 4 and 8 years in a UK birth cohort study. *Neurotoxicology*. 2017 Sep;62:162-169. doi: 10.1016/j.neuro.2017.07.003. Epub 2017 Jul 4. PubMed PMID: 28687448; PubMed Central PMCID: PMC5630203.

³⁵ Lidsky TI, Schneider JS. Lead neurotoxicity in children: basic mechanisms and clinical correlates. *Brain*. 2003 Jan;126(Pt 1):5-19. doi: 10.1093/brain/awg014. PMID: 12477693.

³⁶ Neuwirth LS, Phillips GR, El Idrissi A. Perinatal Pb2+ exposure alters the expression of genes related to the neurodevelopmental GABA-shift in postnatal rats. *J Biomed Sci*. 2018 May 24;25(1):45. doi: 10.1186/s12929-018-0450-4. PMID: 29793500; PMCID: PMC5967126.

impacts of “Flint water crisis-associated elevation in blood lead levels” on an individual’s diagnosis of a neurobehavioral disorder. This would specifically require clear evidence of having developed an attention-related behavioral diagnosis or significant worsening of an existing attention-related behavioral diagnosis a minimum of 90 days after their exposure to lead-contaminated Flint tap water began, as well as an individual assessment of the plaintiff to conduct a process of differential etiology with the goal of determining if the exposure more likely than not was a substantial contributing factor to their diagnosis or significant worsening of their diagnosis. In my opinion, the evidence for entertaining this possibility is grounded in the available most rigorous studies of lead exposure and behavior. For example, in a study my team conducted among children 6-13 years of age with a mean blood lead level of 3.4 $\mu\text{g}/\text{dL}$, a 1 $\mu\text{g}/\text{dL}$ increase in blood lead was associated with significantly higher scores on a well-validated diagnostic instrument measuring Hyperactivity and Restless-Impulsivity³⁷. Similar results have been seen in other studies with respect to blood lead levels less than 5 $\mu\text{g}/\text{dL}$

³⁷ Huang S, Hu H, Sánchez BN, Peterson KE, Ettinger AS, Lamadrid-Figueroa H, Schnaas L, Mercado-García A, Wright RO, Basu N, Cantonwine DE, Hernández-Avila M, Téllez-Rojo MM. Childhood Blood Lead Levels and Symptoms of Attention Deficit Hyperactivity Disorder (ADHD): A Cross-Sectional Study of Mexican Children. *Environ Health Perspect.* 2016 Jun;124(6):868-74. doi: 10.1289/ehp.1510067. Epub 2015 Dec 8. PMID: 26645203; PMCID: PMC4892926.

and symptoms of Attention Deficit Hyperactivity Syndrome^{38, 39, 40, 41}. As noted earlier, in its June 2012 systematic review of the health effects of low-level lead exposure, the U.S. National Toxicology Program concluded that “In children, there is sufficient evidence that blood Pb levels <5 µg/dL are associated with decreases in broad based and specific indices of cognitive function and *an increase in attention-related behavioral problems and antisocial behavioral problems*.”⁴² More recent systematic reviews arrived at the same conclusion with respect to low-level lead exposure (i.e., blood lead levels less than 5 or 10 µg/dL) and Attention-Deficit/Hyperactivity Disorder^{43, 44}. I note, however, that the scientific literature examining the dose-response quantitative relationship between levels of lead exposure and either

³⁸ Braun JM, Kahn RS, Froehlich T, Auinger P, Lanphear BP. Exposures to environmental toxicants and attention deficit hyperactivity disorder in U.S. children. *Environ Health Perspect.* 2006 Dec;114(12):1904-9. doi: 10.1289/ehp.9478. PMID: 17185283; PMCID: PMC1764142.

³⁹ Hong SB, Im MH, Kim JW, Park EJ, Shin MS, Kim BN, Yoo HJ, Cho IH, Bhang SY, Hong YC, Cho SC. Environmental lead exposure and attention deficit/hyperactivity disorder symptom domains in a community sample of South Korean school-age children. *Environ Health Perspect.* 2015 Mar;123(3):271-6. doi: 10.1289/ehp.1307420. Epub 2014 Oct 3. PMID: 25280233; PMCID: PMC4348739.

⁴⁰ Ha M, Kwon HJ, Lim MH, Jee YK, Hong YC, Leem JH, Sakong J, Bae JM, Hong SJ, Roh YM, Jo SJ. Low blood levels of lead and mercury and symptoms of attention deficit hyperactivity in children: a report of the children's health and environment research (CHEER). *Neurotoxicology.* 2009 Jan;30(1):31-6. doi: 10.1016/j.neuro.2008.11.011. Epub 2008 Nov 30. PMID: 19100765.

⁴¹ Nigg JT, Knottnerus GM, Martel MM, et al. Low blood lead levels associated with clinically diagnosed attention-deficit/hyperactivity disorder and mediated by weak cognitive control. *Biol Psychiatry.* 2008;63(3):325- 331. doi:10.1016/j.biopsych.2007.07.013

⁴² NTP Monograph. *Health Effects of Low-Level Lead*. US Department of Health and Human Services, National Toxicology Program. June 2012. Available at: https://ntp.niehs.nih.gov/ntp/ohat/lead/final/monographhealtheffectslowlevellead_newissn_508.pdf ; accessed on April 13, 2020.

⁴³ He J, Ning H, Huang R. Low blood lead levels and attention-deficit hyperactivity disorder in children: a systematic review and meta-analysis. *Environ Sci Pollut Res Int.* 2019 Jun;26(18):17875-17884. doi: 10.1007/s11356-017-9799-2. Epub 2017 Aug 5. PMID: 28780688.

⁴⁴ Donzelli G, Carducci A, Llopis-Gonzalez A, Verani M, Llopis-Morales A, Cioni L, Morales-Suárez-Varela M. The Association between Lead and Attention-Deficit/Hyperactivity Disorder: A Systematic Review. *Int J Environ Res Public Health.* 2019 Jan 29;16(3):382. doi: 10.3390/ijerph16030382. PMID: 30700018; PMCID: PMC6388268.

the risk of developing behavioral diagnoses that meet diagnostic criteria or the levels of behavioral symptoms experienced/signs observed is not as robust as it is for lead and IQ. Moreover, unlike IQ, levels of behavioral symptoms are difficult to translate into economic terms. Thus, given that, similar to the blood lead level-IQ relationship, a threshold for lead's adverse impact on behavioral has not been seen even with respect to blood lead levels below 3 $\mu\text{g/dL}$ ⁴⁵, it is my opinion that lead exposure enough to establish an individual as a member of the injured class could very well be enough to have constituted a substantial contributor to a diagnosis of an attention disorder or significant worsening of an existing attention disorder if it can be established that the disorder or significant worsening of the disorder occurred 90 days or more after that individual's onset of lead exposure related to the Flint water crisis, and if the process of differential diagnosis and etiologic assessment was consistent with lead exposure as a substantial contributing factor.

35. I reserve the right to amend my expert report and update my opinions if new or additional information becomes available.

V. LIST OF PUBLICATIONS

1. See Exhibit 2 attached hereto.

⁴⁵ He J, Ning H, Huang R. Low blood lead levels and attention-deficit hyperactivity disorder in children: a systematic review and meta-analysis. *Environ Sci Pollut Res Int*. 2019 Jun;26(18):17875-17884. doi: 10.1007/s11356-017-9799-2. Epub 2017 Aug 5. PMID: 28780688.

VI. LIST OF ALL CASES

1. See Exhibit 3 attached hereto.

VII. STATEMENT OF COMPENSATION PAID

1. See Exhibit 4 attached hereto.

VIII. LIST OF REFERENCES

1. See Exhibit 5 attached hereto.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge and recollection.

Executed this 29th day of June, 2020, in Seattle, WA.


By: 
Howard Hu, M.D., M.P.H., Sc.D.

EXHIBIT 1

CURRICULUM VITAE

Date Prepared: May, 2020

NAME: Howard Hu
HOME ADDRESS: 12544 42nd Avenue NE, Seattle, WA; 98125, USA
DATE OF BIRTH: June 12, 1956

PRIMARY AFFILIATION: School of Public Health, University of Washington
SECONDARY AFFILIATION: School of Public Health, University of Michigan

CONTACT: Howard Hu, M.D, M.P.H., Sc.D.
Email: hhu5@uw.edu

LINKS:
Faculty: <https://deohs.washington.edu/node/20961>
Publications : <https://www.ncbi.nlm.nih.gov/myncbi/1vwnVYvgxfEAw/bibliography/public/>

TABLE OF CONTENTS

SUBJECT	PAGE
EDUCATION	2
POSTDOCTORAL TRAINING	2
CERTIFICATION AND LICENSURE	2
ACADEMIC APPOINTMENTS	2
ADMINISTRATIVE APPOINTMENTS	3
CLINICAL APPOINTMENTS	4
OTHER ACADEMIC POSITION/VISITING APPOINTMENTS	4
MAJOR RESEARCH INTERESTS	5
GRANTS	5
HONORS AND AWARDS	9
MEMBERSHIPS	10
EDITORIAL POSITIONS AND BOARDS	10
PEER REVIEW SERVICE	11
TEACHING	11
COMMITTEE, ORGANIZATIONAL, VOLUNTEER SERVICE	17
OTHER PUBLIC SERVICE	22
CONSULTING POSITIONS	22
VISITING PROFESSORSHIPS	23
SEMINARS AND EXTRAMURAL INVITED PRESENTATIONS	23
BIBLIOGRAPHY	31

EDUCATION:

9/1973-6/1976	Biology	B.Sc.	Brown University
9/1977-6/1982	Medicine	M.D.	Albert Einstein College of Medicine
9/1979-6/1980 (degree in 6/1982*)		M.P.H. (Occ Hlth)	Harvard School of Public Health
9/1985-6/1986	Epidemiology	M.S.	Harvard School of Public Health
7/1986-6/1990	Epidemiology	Sc.D.	Harvard School of Public Health

* Awarding of the Harvard M.P.H. to medical students is delayed until the M.D. degree is conferred

POSTDOCTORAL TRAINING:

Research Fellowships

7/1987-6/1988 Occupational Health Research Fellow, Dept. of Environmental Health
Harvard School of Public Health

Internship and Residencies

7/1982-6/1983	Intern in Medicine	Boston City Hospital
7/1983-6/1984	Junior Assistant Resident, Internal Medicine	Boston City Hospital
7/1984-6/1985	Senior Assistant Resident, Internal Medicine	Boston City Hospital
7/1985-6/1987	Resident, Occupational Medicine	Harvard School of Public Health

CERTIFICATION AND LICENSURE:

1984	Massachusetts Medical License Registration
1985	American Board of Internal Medicine, Diplomate
1987	American Board of Preventive Medicine, Diplomate (Occupational Medicine)
2006	Michigan Medical License Registration
2013	College of Physicians & Surgeons of Ontario
2018	Washington State Medical License Registration

ACADEMIC APPOINTMENTS:

9/1988-6/1992	Instructor in Medicine Department of Medicine, Harvard Medical School
9/1988-6/2006	Associate Physician (Clinical and Research), Channing Laboratory, Department of Medicine, Brigham & Women's Hospital
9/1990-6/1994	Assistant Professor of Occupational Medicine Department of Environmental Health, Harvard School of Public Health
7/1992-6/1997	Assistant Professor of Medicine Department of Medicine, Harvard Medical School

CV: Howard Hu, M.D., M.P.H., Sc.D.

7/1994-6/2002 Associate Professor of Occupational Medicine
Department of Environmental Health, Harvard School of Public Health

7/1997-8/2006 Associate Professor of Medicine
Department of Medicine, Harvard Medical School

7/2002-8/2006 Professor of Occupational and Environmental Medicine (tenured)
Department of Environmental Health, Harvard School of Public Health

9/2006-6/2012 Chair and Professor of Environmental Health Sciences (tenured), Department of
Environmental Health Sciences, University of Michigan School of Public Health

9/2006-8/2009 Adjunct Professor of Occupational and Environmental Medicine
Department of Environmental Health, Harvard School of Public Health

9/2006-6/2012 Research Associate Physician, Channing Laboratory, Department of
Medicine, Brigham & Women's Hospital

5/2007-2012 Professor of Epidemiology, University of Michigan School of Public Health

5/2007-2012 Professor of Internal Medicine, University of Michigan Medical School

1/2009-2012 NSF International Endowed Department Chair, University of Michigan School of
Public Health, Department of Environmental Health Sciences

7/2012-2018 Professor of Environmental Health, Epidemiology and Global Health (tenured)
Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario,
Canada (on sabbatical/administrative leave, 2017-2018)

7/2012-2018 Professor, School of Medicine, University of Toronto, Toronto, Ontario, Canada

7/2012- Adjunct Professor, Department of Environmental Health Sciences, University of
Michigan School of Public Health

7/2012-2013 Director, Dalla Lana School of Public Health, University of Toronto, Toronto,
Ontario, Canada

7/2013-6/2017 Founding Dean, Dalla Lana School of Public Health, a Faculty of the University
of Toronto, Toronto, Ontario, Canada

7/2017- Affiliate Professor (started as a Visiting Scholar, transitioned in 2018),
Department of Occupational and Environmental Health Sciences, University of
Washington School of Public Health, Seattle, WA

ADMINISTRATIVE APPOINTMENTS:

7/1991-6/2006 (Founding) Director, Metals Epidemiology Research Group, Channing Laboratory,
Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, and
Department of Environmental Health, Harvard School of Public Health

7/1992-6/1995 Director, Commission to Investigate the Health and Environmental Effects of Nuclear
Weapons Production, International Physicians for the Prevention of Nuclear War

7/1996-6/2006 Director, Residency Program in Occupational and Environmental Medicine, Harvard
School of Public Health

7/1996-8/2006 Director, Occupational and Environmental Medicine Core, National Institute for
Occupational Safety and Health Educational Resource Center at the Harvard School of
Public Health

7/1998-6/2004 (Founding) Medical Editor, Environmental Health Perspectives (official journal of
NIEHS)

7/2000-8/2006 Associate Director, the Harvard NIEHS Environmental Sciences Center, Harvard
CV: Howard Hu, M.D., M.P.H., Sc.D.

School of Public Health
7/2004-6/2009 (Founding) Principal Investigator and Director, Harvard Center for Children's Environmental Health and Disease Prevention Research (co-PI and co-Director after 9/1/08)
9/2006-6/2012 Chair, Department of Environmental Health Sciences, University of Michigan School of Public Health
9/2006-2012 Director, Occupational Epidemiology Core, NIOSH Education and Research Center, University of Michigan
9/2006-2012 Co-Director, Michigan-Harvard/Harvard-Michigan Metals Epidemiology Research Group
7/2009-2011 Director, NIA T32 Training Grant in Aging and Public Health, University of Michigan School of Public Health
1/2010-2012 Chair, Faculty Steering Committee on Global Health, University of Michigan School of Public Health
4/2011-2012 (Founding PI) and Director, University of Michigan NIEHS P30 Core Center.
7/2012-2013 Director, Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada
7/2013-6/2017 Founding Dean, Dalla Lana School of Public Health, a Faculty of the University of Toronto, Toronto, Ontario, Canada

CLINICAL APPOINTMENTS:

7/1985-6/1987 Attending Physician, Emergency Department, Whidden Memorial Hospital
7/1985-6/1988 Assistant Visiting Physician, Department of Medicine, Boston City Hospital
1/1985-6/2006 Consultant in Occupational and Environmental Medicine, Center for Occupational and Environmental Medicine, Northeast Specialty Hospital (formerly known as the Olympus Specialty Hospital, the Massachusetts Respiratory Hospital, and Norfolk County Hospital).
3/1987-9/1987 Attending Physician, Occupational Health Program, University Hospital/Boston University Medical Center
7/1988-9/2006 Associate Physician, Brigham and Women's Hospital
7/1990-6/1995 Occupational/Environmental Medicine Consultant, Brigham and Women's Hospital Employee Health Services
7/2007-2012 Associate Physician, Division of General Medicine, Department of Medicine, University of Michigan Health System
1/2019-present Staff Physician, RotaClinic-Lake City, Seattle, WA

OTHER ACADEMIC POSITIONS and MAJOR VISITING APPOINTMENTS:

7/1987-6/1990 Visiting Physician, South Cove Health Center, Boston (Chinatown)
7/1996-8/2006 Associate, Center for Health and the Global Environment, Harvard Medical School
2/1997 Alice Hamilton Visiting Professor, Division of Occupational and Environmental Medicine, Department of Medicine, University of California at San Francisco
11/2000- Visiting Scientist, Sri Ramachandra Medical College and Research Institute
7/2010- Senior Consultant, Tianjin Centers for Disease Control and Prevention, Tianjin, CV: Howard Hu, M.D., M.P.H., Sc.D.

China
10/2012- Visiting Professor, Shanghai Key Laboratory of Children's Environmental Health,
Xinhua Hospital, Shanghai Jiao-Tung University, China
7/2013-6/2016 Visiting Professor, Shanghai Jiao Tong School of Medicine, China
5/2015- Affiliate Scientist to the Li Ka Shing Knowledge Institute, St. Michael's Hospital,
Toronto, Canada

MAJOR RESEARCH INTERESTS:

1. Environmental and molecular epidemiologic research related to heavy metals, potential endocrine disruptors, other neurotoxicants, carcinogens, etc.
2. Gene-environment interactions; epigenetic dysregulation
3. Fetal/early life exposures and long-term effects
4. Aging-environment interactions
5. Environmental health, health inequities and health disparities, human rights
6. Health and the global environment
7. "Big Data" for population health
8. Environmental sensitivities/Multiple chemical sensitivities

GRANTS (as PI, Co-PI, or primary mentor only):

Past Funding:

1980 (summer) Montefiore Hospital, Bronx NY, PI; \$2,000 (approx)
A study of rural and occupational health in Tulua, Colombia, South America
1982 (summer) Albert Einstein College of Medicine, PI; \$3,000 (approx)
A study of occupational/environmental health in Shanghai, China
7/1987-6/1989 NIEHS Center Grant ES00002 Pilot Project, PI; \$12,000
The Long-term Renal and Neurologic Effects of Childhood Plumbism
7/1989-6/1990 NIEHS subcontract 7083-1, PI; \$50,000 (approx)
The Use of X-Ray Fluorescence to Measure Lead Burden and Childhood Lead Exposure
7/1990-6/1992 Agency for Toxic Substances and Disease Registry, PI; \$150,000 (approx)
"Clinical Environmental/ Occupational Medicine Research Fellowship Award",
7/1990-6/1991 NIEHS Center Grant ES00002 Pilot Project, PI; \$12,000
The Metabolic Effects of Pregnancy and Lactation on Lead Burden
7/1990-6/1991 Harvard School of Public Health Basic, PI
Research Support Grant; \$10,000
K-X-Ray Fluorescence Measured Lead Burden
10/1991-11/1991 NIOSH Special Grants, PI; \$50,000 (approx)
The Carpenters Lead Project
4/1991-3/1996 NIEHS/R01, PI; \$2,200,000 (approx)
The Epidemiology of Lead, Diet and Blood Pressure
7/1991-6/1996 NIEHS/R01 supplement, PI; \$240,000 (approx)

CV: Howard Hu, M.D., M.P.H., Sc.D.

The Epidemiology of Lead, Diet and Blood
Pressure--Research Supplement for Minority Investigator
7/1992-6/1995 NIEHS/R01 (Office of Research on Women), PI; \$200,000 (approx)
Lead and Hypertension in Women
7/1993-6/1996 NIEHS/subcontract, PI; \$150,000 (approx)
Exposure to Neurotoxins as Risk Factors for Amyotrophic Lateral Sclerosis
7/1995-6/1998 State of Washington, Department of Labor, PI; \$350,000 (approx)
SPECT Imaging of the Brain in Patients with Multiple Chemical Sensitivity
Syndrome and Controls
7/1996-6/1997 NIEHS Center Grant ES00002 Pilot Project, PI; \$15,000
Electrocardiographic abnormalities in association with low-level lead exposure
among middle-aged to elderly men: the Normative Aging Study
4/1995-3/2000 NIEHS Project PI (Program Project PI: Richard Monson); \$1,800,000 (approx)
Lead Exposure, Accumulation in Bone, and Reproductive Toxicity Among Men and
Women In Mexico
4/1995-3/2000 NIEHS Project PI (Program Project PI: Richard Monson); \$1,900,000 (approx)
Lead Exposure, Accumulation in Bone, and Cognitive Toxicity Among Elderly Men
and Women
6/1997-5/2002 NIEHS/R01 ES05257 PI; \$2,312,274
Lead Biomarkers, Aging, and Chronic Disease
7/1997-6/1999 NIEHS Center Grant ES00002 Pilot Project, PI; \$10,000
The effect of genetic polymorphisms of metallothionein-IIA on mRNA levels in
middle-aged to elderly men: the Normative Aging Study
7/1998-6/2003 NIEHS/R01 PI (with no-cost extension; 5R01ES007821); \$2,291,833
Lead Dose Biomarkers, Reproduction, and Infant Outcomes
7/1999-6/2000 NIEHS Center Grant ES00002 Pilot Project, co-PI; \$14,000
Magnetic Resonance Spectroscopy in the Evaluation of Lead Neurotoxicity: the
Normative Aging Study
7/2000-6/2001 MAVERIC (Massachusetts Area Veterans Epidemiology Resource and Institute
Center) Pilot Project PI (with Dr. Robert Wright, co-PI); \$10,000
The Use of Magnetic Resonance Spectroscopy in Lead Poisoning
7/2000-6/2001 NIOSH Center Grant Pilot Project, PI (with Dr. Robert Wright, co-PI); \$12,000
Interaction between ApoE Genotype and Lead Exposure in the Development of
Cognitive Impairment
7/2002-6/2004 The Rasmussen Foundation/Health Care Without Harm; \$50,000
Medical Use of Phthalate Containing Products in the Neonatal Intensive Care Unit
and Biomarkers of Neonatal Phthalate Metabolites
7/2002-6/2003 NIEHS Center Grant Pilot Project, PI; \$8,000
Vitamin D Receptor Gene and Bone Lead in Reproduction
3/2004-2/2005 The Critelli Family Foundation; \$10,000
Review of Environmental Cadmium Exposure and Toxicity
4/2000-3/2007 NIEHS Project Leader (Program Project PI: Richard Monson; 5P01ES05947);
\$2,472,677; Controlled Trial in Pregnancy of Dietary Supplements for the
Suppression of Bone Resorption and Mobilization of Lead into Plasma (no cost
extension)

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7

- 4/2000-3/2007 NIEHS Project co-Leader (Program Project PI: Richard Monson; 5P01ES05947); \$1,210,000 (approx); A Community-Based Study of Lead Exposure Pathways, Biomarkers of Dose, Health Effects, and Phytoremediation Strategies at the Tar Creek Superfund Site (no cost extension)
- 4/2002-9/2007 NIEHS/R01 PI (5R01ES010798); \$3,011,295
Gene-Metal Interactions and Parkinson's Disease
- 10/2003-9/2007 NCMHI/P20 Project Leader (MD000501-01; Hughes Harris, PI); \$828,781 (Project)
"FAMU and Harvard Center for Health and Health Care Disparities"
- 8/2003-7/2008 NIEHS/R01 PI (2R01ES05257-11A2); \$3,357,424 (became co-PI in 2007 after move to University of Michigan)
Lead-Gene Interactions and Cognition
- 6/2004-3/2009 NIEHS/P01 PI (5 P01ES012874-01); \$6,662,670 (became co-PI in 2006 after move to University of Michigan)
Metals Mixtures and Children's Health (Center for Children's Environmental Health and Disease Prevention Research)
- 7/2002-12/2009 NIH/R03 PI (1R03TW005914; no cost ext through 2008); \$192,000 (approx)
Lead, Genes, and Cognition in Children in Chennai, India
- 9/2006-7/2011 NIEHS/R01 PI (R01ES0007821); \$3,116,831
Fetal Origins of Neurobehavior: Lead and Cholesterol Metabolism Interactions
- 7/2006-6/2011 NIEHS/R01 co-PI (R01ES013744; PI Wright), \$3,200,000
Stress, Lead, Iron Deficiency and Neurodevelopment
- 7/2006-6/2011 NIEHS/R01 co-PI (R01ES014930; PI Wright), \$2,800,000
Metal Mixtures and Neurodevelopment
- 2/2008-2/2010 Michigan Institute for Clinical and Health Research (MICHR; home of the UM CTSA; UL1RR024986) Pilot Project PI; \$26,000 (no cost extension)
Epigenetics of Early Life Events and Environmental Toxicants
- 4/2009-4/2010 Michigan Alzheimer's Disease Research Center Pilot Project PI, \$25,000
Environment, Epigenetics and Alzheimer's Disease (no cost extension)
- 12/2009-12/2010 University of Michigan Center for Global Health Pilot Project PI, \$25,000
Climate Variability and Impacts on Mortality and Morbidity in Chennai, India: A Pilot Project Stemming from the 2009 U.S.-India Workshop on Climate Change and Public Health, Goa India (no cost extension)
- 9/2009-9/2010 Michigan Institute for Clinical and Health Research (MICHR; home of the UM CTSA; UL1RR024986) Pilot Project PI; \$26,000 (no cost extension)
Epigenetics and Epigenomics in the Etiology of Alzheimer Disease
- 7/2008-6/2011 NIA/T32 PI (T32AG027708); \$450,000
Interdisciplinary Training Program in Aging and Public Health
- 4/2010-3/2015 NIEHS P42 Superfund Co-Inv, Project 2, Co-investigator (P42ES017198; PI: Alshawabkeh, Project 2 Leader: Meeker) Puerto Rico Testsite For Exploring Contaminant Threats, \$12,000,000
- 4/1/2011-6/2015 NIEHS Core Environmental Health Sciences Center, Founding PI and Director (until 2012; now consultant; P30 ES017885), \$ 4,620,100;
"Lifestyle Exposures and Adult Disease"
- 4/2010-3/2014 NIEHS/EPA P20 Co-PI and Clin Health Specialist (P20 ES018171; PI Peterson)

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CV: Howard Hu

8

Formative Children's Environmental Health and Disease Prevention Center,
\$1,959,960; "Perinatal Exposures, Epigenetics, Child Obesity & Sexual Maturation"
7/1/2013-6/30/2014 CIHR, Canadian Institute for Health Services and Policy Research; Planning
Grants-Priority Announcement:Partnerships for Health System Improvement; PI, \$24,992
"The Surviving Opioid Overdose with Naloxone (SOON) Project and Roundtable"
07/1/11-06/30/16 NIEHS K01 ES019909 (co-mentor; PI: Somers)
"Immune dysfunction associated with early life heavy metal exposure"
4/1/12-3/30/17 NIEHS R01ES013744 (consultant; PI: Wright; Mt Sinai School of Medicine)
"Stress-Lead Interactions and Child Development"
7/1/2012-7/1/2017 European Commission (EC), Funded under FP7-Health, Project 304925, co-
Investigator; PI, epidemiologic studies, \$6,000,000 E
"A novel micronutrient-based strategy to prevent hearing impairments: test and road to
market for age-related hearing loss and preservation of residual hearing"

Current Funding

3/24/2020-2/28/2021 Pilot Project Proposal for Rapid Response Funding, University of Michigan
NIEHS P30 Core Sciences Center (co-PI); \$6,250, "Environmental Cadmium and
Influenza-related Mortality in NHANES: An Environment-Infectious Disease Interaction
Study with Implications for Strategies for Reducing COVID-19-related Morbidity and
Mortality"
6/1/2012-7/1/2019, in NCE 1R01ES021446, PI, \$4,140,000 (parent + supplement awards);
"Prenatal and Childhood Exposure to Fluoride and Neurodevelopment"
5/15/2015-5/15/2019, in NCE Health Canada; PI, \$200,000 (Phase 1); \$1,400,000 (proposed Phase
2) "A Community-based First Nation Study of Cancer and the Environment in Northern
Ontario"
4/1/13-3/31/23NIEHS/EPA P01ES022844 (co-inv; PI: Peterson at the University of Michigan)
"Lifecourse Exposures & Diet: Epigenetics, Maturation & Metabolic Syndrome."
7/1/16-6/30/21 CIHR (co-PI; Director; PI: Jeffrey Brook at the Dalla Lana School of Public
Health) \$4,700,000 CNDN
"CANadian Urban Environmental (CANUE) Health Research Consortium"
9/1/16-8/31/21 NIH 5R01ES026033-02, (Consultant/Co-investigator; PI: Arora at Mt. Sinai School
of Medicine) \$648,000 "Novel Biomarker to Identify Critical Windows of Susceptibility
to Metal Mixture"
9/1/17-6/30/22 NIH R24ES028502 (Consultant/Co-investigator; PI: Peterson at the University of
Michigan, "E3GEN: Multigenerational Effects of Toxicant Exposures on Life Course
Health and Neurocognitive Outcomes in the ELEMENT Birth Cohorts"; \$2,009,022

Applications Under Review

Wellcome Trust, co-investigator (PI: P Landrigan)
"Quantifying the Cognitive and Economic Benefits of Reducing Air Pollution to Achieve
Climate Change Mitigation"

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CV: Howard Hu

9

R01ES031820 (app # pending), multiple PI, \$3,086,477
Perinatal Maternal Heavy Metal Burden and Offspring Blood Pressure

Competitive Renewal Applications In Progress

R01ES021446-01, PI, \$4,140,000
A Prospective Study of Early Life Exposure to Fluoride, Thyroid Function, and
Neurobehavioral Outcomes

Amended Application In Progress

New Application in Progress

Wellcome Trust, xxx, multiple-PI
Addressing Two Critical Gaps in Understanding the Impacts of Lead Exposure on the
Global Burden of Disease: (a) Impacts on Cardiovascular Disease; (b) Exposures and
Sources in Low and Middle-Income Countries

HONORS AND AWARDS:

1978-1982 National Health Service Corps Scholarship
1985-1988 National Research Service Award
1990-1992 Agency for Toxic Substances and Disease Registry Clinical Environmental Medicine
Award
1994 Will Solimene Award of Excellence, American Medical Writers Association, for:
Chivian E, McCally M, Hu H, Haines H, eds. *Critical Condition: Human Health and the
Environment*. Cambridge: The MIT Press, 1993.
1997 Alice Hamilton Lecturer, University of California at San Francisco
1998 First Prize for Best Infant Nutrition Research, Instituto Danone, Mexico (for González-
Cossío T, Peterson KE, Sanín L, Fishbein SE, Palazuelos E, Aro A, Hernández-Avila M,
Hu H. "Decrease in birth weight in relation to maternal bone lead burden." Published in
Pediatrics)
1999 National Institute for Environmental Health Sciences "Progress and Achievement of the
Year Award", 1998-1999
1999 True Memorial Lecturer, Maine Medical Center, Portland ME.
2000-2001 Faculty Sabbatical Award, Harvard School of Public Health
2000-2001 Senior Fulbright Scholar in India
2001 Hoopes Prize, Faculty Mentorship (for Senior Thesis of Charles Lin, "More than Black
and White: Lead Poisoning as an Environmental Justice Issue in Boston")
2003 Best Paper in Preventive Medicine by a Medical Student (for Senior Thesis of Vanitha
Janakiraman; Janakiraman V, Hu H, Mercado-Garcia A, Hernandez-Avila M. A
randomized crossover trial of nocturnal calcium supplements to suppress bone resorption

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10

- during pregnancy. Am J Prev Med 2003;24:260-4.). American College of Preventive Medicine, Ulrich and Ruth Frank Foundation for International Health.
- 2004 Das Travel Grant Award, The South Asia Initiative, Harvard University (for Travel in India)
- 2005 Adolph G. Kammer Merit in Authorship Award, the American College of Occupational and Environmental Medicine (for Rhodes D, Spiro A, Aro A, Hu H "Relationship of Bone and Blood Lead Levels to Psychiatric Symptoms: The Normative Aging Study", Published in the *Journal of Occupational and Environmental Medicine*)
- 2006 Teacher of the Year Award, Occupational/Environmental Medicine Residents, Harvard School of Public Health
- 2006 Harriett Hardy Award, the New England College of Occupational and Environmental Medicine
- 2009 Linus Pauling Award for Lifetime Achievements, American College for the Advancement of Medicine
- 2011 Award for Excellence, American Public Health Association
- 2015 John R. Goldsmith Award for Outstanding Contributions to Environmental Epidemiology, International Society for Environmental Epidemiology
- 2016 Election to Fellowship, Canadian Academy of Health Sciences

MEMBERSHIPS IN PROFESSIONAL SOCIETIES

Memberships

- 1981- American Public Health Association (APHA)
- 1982-2006 Massachusetts Coalition for Occupational Safety and Health
- 1983-1989 American College of Physicians
- 1985- Physicians for Social Responsibility
- 1987- Physicians for Human Rights
- 1990- International Society for Environmental Epidemiology (ISEE)
- 1990-2000 American Association for the Advancement of Science
- 1990-2006 Association of Occupational and Environmental Clinics (AOEC)
- 1991- International Physicians for the Prevention of Nuclear War (IPPNW)
- 1994-1996 Society for Occupational and Environmental Health (SOEH)
- 2000-2012 American College of Occupational and Environmental Medicine (ACOEM)
- 2009-2012 Society of Toxicology
- 2012- Canadian Public Health Association (CPHA)
- 2020- Washington State Medical Association

Committee Assignments

- 1981-1982 Program Committee, Occupational Safety and Health Section, APHA
- 1987-1988 Program Committee, Asian-American Caucus, APHA
- 1992-1998 Membership Committee, ISEE

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11

1995-1998 Quality Assurance Committee, AOEC
1997-1998 Program Committee, 1998 Superfund Basic Research Program, Annual National Meeting
2001-2006 Program Committee, New England College of Occupational and Environmental Medicine
Annual Meetings

EDITORIAL POSITIONS AND BOARDS:

1977-1982 Einstein Community Health Newsletter
1988-1992 Bookreview Co-Editor, Section on Occupational Safety and Health, Am Public Health
Assoc.
1993- Journal of Health and Human Rights
1998- Environmental Health Perspectives (Founding Medical Editor, 1998-2004; Associated
Editor, 2004-)
2004- American Journal of Industrial Medicine
2007-2009 Faculty of 1000 Medicine
2017- Current Environmental Health Reports
2017- Faculty of 1000 Medicine

PEER REVIEW SERVICE

American Journal of Epidemiology
American Journal of Industrial Medicine
Archives of Environmental and Occupational Health
Biomed Central
Circulation
Environmental Health
Environmental Health Perspectives
Environment International
Environmental Research
Epidemiology
Indian Journal of Medical Research
Journal of Health and Human Rights
Journal of the American Medical Association
Kidney International
Lancet
New England Journal of Medicine
Pediatrics
PLOS One
Science of the Total Environment

TEACHING:

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12

1. LOCAL CONTRIBUTIONS (at the Harvard School of Public Health, 1985-2006)

1985- "Toxicology of the Kidney and Urinary Tract"
Guest Lecturer for TOX204a,b

1988- "Occupational Health"
Guest Lecturer for EH201a,b

1989-1992 "Lead Toxicology"
Guest Lecturer for TOX204a,b

1990- Grand Rounds in Occupational/Environmental Medicine
Director

1990-2000 Introduction to Occupational and Environmental Medicine (EH232c,d)
Course director, lecturer

1990- "The Epidemiology of Lead Exposure, Dose, and Toxicity"
Guest Lecturer for EPE215c,d and EPE215t

1990- "Solvent toxicity"
Fundamentals of Industrial Hygiene, Continuing Education Department

1992 "Current Research on Lead", Metals Epidemiology Research Group Seminar
Presenter

1992 "Lead Poisoning Without a Known Source in a Hyperthyroid Patient"
Case discussant, Grand Rounds in Occupational and Environmental Medicine

1992- "Biological Markers of Lead Dose"
Guest Lecturer, EHE280c,d

1994- "Screening for Lead Toxicity"
Guest lecturer, EPI227d

1994- "Lead Exposure and Biological Monitoring"
Guest Lecturer, ID263b

1994- "Case Study: Lead"
Guest Lecturer and Case Discussant, EH202d

1996- Introduction to Environmental Health (EH201b)
Course director and lecturer

1997- Human Health and Global Environment Change (EH278a,b)
Course Co-developer, Co-director, and lecturer

Hospital courses and Invited Teaching Presentations (Harvard-affiliated Hospitals)

1990 Guest Lecturer on Occupational Medicine
Residency Program, Department of Medicine, Brigham and Women's Hospital

1994 Speaker, Grand Rounds; "Is Lead a Ticking Time Bomb?"
Department of Obstetrics and Gynecology, Brigham and Women's Hospital

1994 Speaker, Grand Rounds; "Is Lead a Ticking Time Bomb?"
Department of Medicine, Brockton V.A. Hospital

1994 Speaker, Symposium on Preventive Medicine and Clinical Epidemiology.; "Is Lead a Ticking Time Bomb"; Brigham and Women's Hospital

1995 Discussant, "Multiple Chemical Sensitivity", Occupational/Environmental Medicine

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13

- 1996 Grand Rounds, Occupational Health Program, Harvard School of Public Health
Guest lecturer, "Lead Toxicity as a Paradigm for a Regional and Global Health Hazard", Environmental Health Student Group, Holmes Society, Harvard Medical School
- 1997 Speaker, "Mobilization of maternal bone lead as a hazard to the fetus", Grand Rounds, Dept. of Neonatology, Beth Israel Hospital, Boston, MA
- 2000 Guest lecturer, "Update on Lead Toxicity Research", Program in Pediatric Toxicology, Children's Hospital
- 2000 Discussant, "Adult Lead Toxicity", Weekly Case Round, Department of Medicine, Brigham and Women's Hospital, Boston.
- 2000 Lecturer, "Update on Lead Toxicity, Hypertension, and Chronic Renal Failure", Renal Rounds, Division of Nephrology, Department of Medicine, Brigham and Women's Hospital, Boston.
- 2002 Lecturer, "Maternal Bone Lead as a Threat to Fetal Development", Program in Neonatology, Beth Israel-Deaconess Hospital, Boston, MA

Doctoral student committees

Chair and member:

- Dr. Rokho Kim Dr.P.H. Occupational Health and Epidemiology, '96
- Dr. Yawen Cheng Sc.D. Epidemiology, '98
- Dr. Sharon Tsaih Sc.D. Epidemiology, '99
- Dr. Hung Yi Chuang Sc.D. Occupational Health, '99
- Dr. Adrienne Ettinger Sc.D. Environmental Health, '03
- Dr. Florence Wang Sc.D. Environmental Health, '05
- Dr. Sung K. Park Sc.D. Environmental Health, '05
- Dr. Pradeep Rajan, Sc.D. Occupational Health, '06

Member/Advisor:

- Dr. How Ran Guo Sc.D. Occupational Health, '94
- Dr. Joshua Cohen Sc.D. Health Policy and Management, '94
- Dr. Jane Hoppin Sc.D. Environmental Health, '95
- Dr. Salma Elreedy Sc.D. Environmental Health, '97
- Dr. Mary Jean Brown Sc.D. Maternal and Child Health, '00
- Dr. Brisa Sanchez Sc.D. Biostatistics, '06
- Dr. Ami Zota Sc.D. Environmental Health, '07
- Dr. Ananya Roy Sc.D. Environmental Health, '08
- Dr. Elissa Wilker Sc.D. Environmental Health, '09

Post-doctoral fellow mentor:

Dr. Marinelle Payton (Channing Lab), Dr. Susan Korrick (Channing Lab), Dr. Rokho Kim (Channing Lab), Dr. Viji Potula (HSPH Research Fellow), Dr. Barbara Nowak (Visiting Scientist from Silesian University School of Medicine, Poland), Dr. Robert Wright (Channing Lab), Dr. Ming Tsuang Wu (HSPH Research Fellow), Dr. Yawen Cheng (Channing Lab), Dr. Geeta Mathur (neonatology fellow at the Brigham and Women's Hospital), Dr. Sri Hari Bojja (HSPH Research

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14

Fellow), Dr. Hae-Kwan Cheong (Visiting Scientist from Dongguk University School of Medicine, S. Korea), Dr. Sahar Elmarsafawy (HSPH Research Fellow), Dr. Jing Lu (Visiting Scientist from the Chinese Academy of Preventive Medicine), Dr. Dieter Affeln (Occ/Env Med Fellow), Dr. Ahmed Gomaa (Occ/Env Med Fellow), Dr. Chris Leffler (Occ/Env Med Fellow), Dr. Ronald Dykeman (Occ/Env Med Fellow), Dr. Uma Dhanabalan (Occ/Env Med Fellow), Dr. Hsien-Wen Hsu (Occ/Env Med Fellow), Dr. Betty Ann Cohen (Occ/Env Med Fellow), Dr. Arvin Chin (Occ/Env Med Fellow), Dr. Daniel Rhodes (Occ/Env Med Fellow), Dr. Richard Wittman (Occ/Env Med Fellow), Dr. Sun-Dong Lee (Visiting Scientist from Sangji University, Korea), Dr. Ronald Green (Occ/Env Med Fellow), Dr. Erma Lawson (Environmental Health Fellow), Dr. Marc Weisskopf (Environmental Health Fellow), Dr. Bridget Bagert (Occ/Env Med Fellow), Dr. John Jarrell (Visiting Scientist from University of Calgary), Dr. Jennifer Weuve (Environmental Health Fellow), Dr. Karen Chou (Visiting Scientist from Michigan State), Dr. Nitin Jain (Channing Laboratory Fellow), Dr. Adrienne Ettinger (Children's Center Scientist), Dr. Sam Myers (Fellow in Alternative and Complementary Medicine), Dr. Marcelo Targino (Occ/Env Med Fellow), Dr. Manish Arora (Post-doctoral fellow from University of Sydney), Dr. Huiling Nie (Post-doctoral fellow from McMaster University).

Other faculty mentorship:

Elizabeth Rubinstein (HMS Summer research), Alicia Marier (HMS Summer research), Vanitha Janakiraman (HMS Summer research), Young-Sook Lim (Harvard College Summer research), Charles Lin (Harvard College Senior thesis research), Ed Hsieh (Harvard College Summer research), Naveen Thomas (Emory University Medical School Senior thesis research), Shreekrishna Akilesh (Harvard Dental School summer research), Christine Pace (HMS Summer research)

Advisory and supervisory responsibilities

1985-1987	Attending Physician, outpatient general medicine clinic, Boston City Hospital; weekly precepting for housestaff and medical students
1990-2006	Preceptor, Residency in Occupational and Environmental Medicine, Harvard School of Public Health at the Mass Respiratory Hospital
1990-2006	Advisor to general M.P.H. students, Harvard School of Public Health.

2. LOCAL CONTRIBUTIONS (at the University of Michigan, 2006-2012)

2006-	<u>Principles of Environmental Health (EHS-500)</u> Course director and lecturer
2006-	Environmental Epidemiology (EHS-608) Guest lecturer on birth cohorts and environmental epidemiology
2006-	Occupational and Environmental Disease (EHS-501) Guest lecturer on metals exposure and health effects; Course Director (2009-)
2007-	<u>Metals Exposure, Biomarkers and Toxicity: A Multi-disciplinary Environmental Epidemiology Approach (EHS-698 reading course)</u> Course director and lecturer
2008-2009,	<u>Topics in Environmental Health Sciences (EHS-688)</u>
2010-2011	Course director and lecturer
2009	<u>Occupational and Environmental Disease (EHS-501)</u>

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15

- 2009- Course director and lecturer
On-line (Long-distance Foundations in Public Health Certificate Program): Principles of Environmental Health (EHS-500-801)
- 2009 Course director and lecturer
Introduction to Public Health (HMP-200)
- 2009- Guest lecturer on environmental health
Seminars in Aging and Public Health (EPID 813)
- 2011 Course director and lecturer
Seminar on Public Health in China (HMP-xxx)
Guest lecturer on “Environmental Health in China”

Post-doctoral fellow mentor:

Dr. Sung Kyun Park (Environmental Health Sciences Fellow, now Research Assistant Professor), Dr. Brisa Sanchez (Biostats Research Assistant Professor, now Assistant Professor), Dr. Richard Pilsner (Robert Wood Johnson Health & Society Fellow), Dr. Aimin Zhang (Environmental Health Sciences Fellow, Toxicology Training Grant), Dr. Ananya Roy (Environmental Health Sciences Fellow), Dr. David Cantonwine (Reproductive Sciences Fellow).

Doctoral Student Advisor (principal)

- | | |
|--------------------|---|
| David Cantonwine | Ph.D. Environmental Health Sciences (2009) |
| Myriam Afeiche | Ph.D. Environmental Health Sciences (co-mentor with Karen Peterson; 2010) |
| Yoon-Hyeong Choi | Ph.D. Environmental Health Sciences (co-mentor with Sung Kyun Park; 2011) |
| Katie F. Bush | Ph.D. Environmental Health Sciences (co-mentor with Marie O’Neill; 2011) |
| Kelly Bakulski | Ph.D. Environmental Health Sciences (2012) |
| Gamola Fortenberry | Ph.D. Environmental Health Sciences (co-mentor with John Meeker; 2013) |
| Siying Huang | Ph.D. Environmental Health Sciences (2013) |
| Deena Thomas | Ph.D. Environmental Health Sciences (2014) |
| Rebecca Tutino | Ph.D. Environmental Health Sciences (2015) |
| Zishaan Farooqui | Ph.D. MD-PhD Medical Scientist Training Program (2015) |

Masters Student Thesis Advisor

Bradley Lampe (OEE), Troy Meissner (OEE), Pheba Alexander (OEE), Brian Davis (OEE & HBHE), Aaron Leftwich (OJOC program), Suengwon Lee (Nutrition), Allen Zhong (OEE), Graham Newman (OEE), Jacqueline Barkoski (OEE)

Undergraduate Thesis Advisor

Lauren Schwartz (Neuroscience, LSA)

3. LOCAL CONTRIBUTIONS (at the University of Toronto, 2012-present)

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16

- 2012 Determinants of Community Health (Faculty of Medicine)
Guest lecturer on ‘The Future of Medicine & Public Health in a Crowded, Diverse, Aging, Stratified, Urbanized, Polluted, Hot, Thirsty, Hungry, Debt-Ridden World’.
- 2012- CHL5004H Introduction to Public Health
Guest lecturer on “The Future of Public Health (and Your Role !) in a Hot, Flat, Crowded...and Diverse, Aging, Stratified, Urbanized, Polluted, Thirsty, Hungry, Debt-Ridden World”. “What is Public Health?”, “Climate Change and Health”
- 2012- CHL 5912F Industrial Toxicology.
Guest lecturer on the “Toxicology of Metals”.
- 2013-2014 Department of Family & Community Medicine “Building Blocks” (short course for International post-graduate primary care trainees); Guest lecturer on “Public Health & Primary Care”
- 2013- CHL5701H Doctoral Seminar, Collaborative Doctoral Program in Global Health
Guest lecturer on “The Challenges of Environmental Health in a Rapidly-Changing World, from the Molecular to the Global”.
- 2014 JCR1000 “Interdisciplinary Approach to Global Challenges”
Guest lecturer on “Global Environmental Health”
- 2014- PHS100H1 “Grand Opportunities in Global Health”; Guest lecturer on “Urban Environments”
- 2015 Public Health & Preventive Medicine Residency Rounds “Physicians, Climate, and other Global Environmental Changes: Our Role”
- 2016 CHL5004H Introduction to Public Health, Course Co-Director (with Professor Erica DiRuggiero)
- 2016 CHL 7001H F6 Environmental-Molecular Epidemiology, Course Co-Moderator (with Professor Morteza Bashash)
- 2016 CHL5701H Doctoral Seminar, Collaborative Doctoral Program in Global Health, Course Co-Director (with Professors Erica DiRuggiero and Abdallah Daar)
- 2016 Joint Seminar, “The Impact on Intelligence, Behaviour, and Society of Lead Exposure: A Case Study of a Global Pollutant and On-going Research”; Collaborative Program in Neurosciences and Collaborative Global Health Doctoral Program, University of Toronto
- 2016 CHL5420H “Global Health Research Methods”
Guest lecturer on “The Early Life Exposures in Mexico to Environmental Toxicants Project (ELEMENT): A Global Health Collaboration Case Study”

Masters student research advisor

Maelle Marchand

Doctoral student advisor

Adele Carty

Doctoral student thesis committee member

Laura Bogaert

Doctoral student thesis examination committee member

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17

Claudie CY Wong (doctoral student in epidemiology, Jockey School of Public Health and Primary Care, Chinese University of Hong Kong)

Zilong Zhang (doctoral student in epidemiology, Jockey School of Public Health and Primary Care, Chinese University of Hong Kong)

Post-doctoral fellow mentor:

Siying Huang, Ph.D.; Morteza Bashash, Ph.D.; Roman Pabayo, Sc.D. (Harvard School of Public Health); Tripler Pell, M.D., M.P.H.

4. LOCAL CONTRIBUTIONS (at the University of Washington, 2017-present)

Doctoral student thesis research mentor

Megan Suter

Doctoral student special projects advisor

Rachel Shaffer

Joey Frostad

Rebecca De Buen

5. NIH K-grant mentorship:

Robert Wright, M.D., M.P.H. (K-23 ES000381, “*Neurochemical and Genetic Markers of Lead Toxicity*”), 2000-2005; Dr. Wright is now Prof of Pediatrics, Mt. Sinai School of Medicine

Marc Weisskopf, Ph.D. (K-01 ES012653, “*New Biomarkers of Neurotoxicity*”), 2004-2009; Dr. Weisskopf is now Associate Prof of Occup Health, Harvard Sch Public Health

Sung Kyun Park, Sc.D. (K-01 ES016587; “*Environment, Novel Aging Outcomes, and Genetics*”), 2009-2014; Dr. Park is now Assistant Prof, Department of Epidemiology, University of Michigan Sch Public Health

Emily Somers, Ph.D. (K-01 ES019909; “*Immune Dysfunction Associated with Early Life Heavy Metals Exposure*”), 2011-2016; Dr. Somers is now Associate Prof, Division of Rheumatology, Department of Internal Medicine, University of Michigan Medical School

COMMITTEE, ORGANIZATIONAL, AND VOLUNTEER SERVICE

National/International

1978-1982 Taskforce on Occupational and Environmental Health, Co-coordinator, Am Med Stu Assoc

1989 Ad Hoc Study Committee, National Institute for Environmental Health Sciences Council
1989-2006 Association of Occupational and Environmental Medicine Clinics (AOEC)-- (through the Northeast Specialty Hospital Center for Occupational and Environmental Medicine)

1989-1990 Member, Relative Risk Reduction Strategies Committee, Science Advisory Board, U.S. Environmental Protection Agency

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18

- 1989-1992 Member, Board of Directors, Physicians for Human Rights, Boston, MA
- 1991 National Institutes of Health, General Clinical Research Center Program, Site Visit Team
- 1992-2019 Member, National Advisory Committee, Physicians for Human Rights, Boston, MA
- 1992 Special Study Section member (R3/S1/B3), National Institutes of Health
- 1994 Ad Hoc Reviewer, National Institutes of Health, General Dental Research Center Program
- 1994- Advisory Board, Institute for Energy and Environmental Research
- 1994-1996 Associate, Project on Global Environmental Change and Health, Physicians for Social Responsibility
- 1995 Ad Hoc Reviewer, National Institutes of Health, Diagnostic Radiology Study Section
- 1996- Membor, Editorial Board, Health and Human Rights—an International Journal
- 1995-1998 Advisory Committee, Consortium for Environmental Education in Medicine, Cambridge, MA.
- 1996-1997 Reviewer, Agency for Toxic Substances and Disease Registry
- 1997-1998 Program Committee, Annual Mtg, NIEHS Superfund Basic Research Group Centers
- 1998-2013 (Founding) Medical Editor (1998-2004); Associated Medical Editor (2004-), Environmental Health Perspectives (official journal of NIEHS)
- 2001 Ad Hoc Reviewer, National Institutes of Health, R-13 applications
- 2002-2006 External Advisory Committee, Program Project on Lead and Osteoporosis, University of Rochester
- 2003-2005 Member, Ad-Hoc Expert Panel to Form Medical Management Guidelines for Lead-Exposed Adults, (supported by NIOSH and AOEC)
- 2003-2009 Member, Working Group on Lead and Pregnancy, Advisory Committee on Childhood Lead Poisoning Prevention, U.S. Centers for Disease Control and Prevention
- 2004 Ad Hoc Reviewer, National Institutes of Health, K-23 applications
- 2004 Ad Hoc Reviewer, Draft of “Immunization Safety Review: Vaccines and Autism” Immunization Safety Review Committee, Institute of Medicine, National Academies of Science
- 2004 Finalist (one of 8), Search for Director, National Institute for Environmental Health Sciences, U.S. National Institutes of Health
- 2005 Member, Strategic Planning Conference, National Institute for Environmental Health Sciences, Research Triangle Park, NC
- 2006 Ad Hoc Reviewer, Draft of “Preterm Birth: Causes, Consequence, and Prevention” Committee on Understanding Premature Birth and Assuring Health Outcomes, Institute of Medicine, National Academies of Science
- 2006 Member, External Advisory Committee, NIEHS Center, University of Rochester
- 2007 Member, Ad Hoc Study Section, Special Emphasis Panel/Scientific Review Group 2007/05 ZES1 JAB-C (DI) (NIEHS Discover Centers)
- 2007-2010 Member, Board on Population Health and Public Health Practice, Institute of Medicine, National Academies, Washington DC.
- 2007 Member, Ad Hoc Review Panel, Centers of Excellence Program, Swedish Council for Working Life and Social Research.
- 2007-2008 Member, Search Committee for Director of Extramural Research, NIEHS
- 2007 Special Consultant, Ad Hoc Study Section, Special Emphasis Panel/Scientific Review

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19

- Group 2008/01 ZAR1 CHW-G (NIAMS Arthritis Centers)
- 2008 Report Reviewer, Draft National Research Council Report, "The National Children's Study Research Plan: A Review", National Academies
- 2008 Report Reviewer, Draft National Research Council Report, "Gulf War and Health: Updated Literature Review of Depleted Uranium", Institute of Medicine, National Academies
- 2008-2009 Data Safety Monitoring Board, "d-Penicillamine Chelation in lead-poisoned Children—A Phase II/III Trial" (R01FD003361; PI: Michael Shannon)
- 2008 Subcommittee to review Draft Report on Bisphenol A, Science Board, Food and Drug Administration
- 2008 Planning Committee, International Symposium on the Environmental and Health Consequences of Metal Mining and Smelting
- 2008-2009 Co-Chair, Planning Committee, "Climate Change Impacts on Public Health in India", Workshop that took place in Goa, India in Aug-Sept 2009 co-sponsored by UM Center for Global Health, the US Centers for Disease Control and Prevention and the Indian Council for Medical Research
- 2008 Finalist (one of 2), Search for Director, National Institute for Environmental Health Sciences, U.S. National Institutes of Health
- 2009-2012 Member, Board on Environmental Studies and Toxicology, National Research Council
- 2009 Reviewer, NIH Challenge Grants, Special Emphasis Panel/Scientific Review Group 2009/10 ZRG1 GGG-F
- 2009-2010 External Member, Academic Program Review Site Visit Committee, Department of Environmental and Occupational Health Sciences, University of Washington School of Public Health
- 2010-2012 Member, External Advisory Committee, University of Rochester NIEHS P30 Core Center
- 2010 Member, Ad-hoc review committee, National Health Research Institutes of Taiwan, Special Emphasis Panel—NHRI-Kaoshiung Medical College Program Project on “: “Gene Environment Interaction in the Genesis of Asthma and Allergic Diseases”
- 2010-2012 Member, Advisory Board, Institute of Public Health, Florida Agricultural & Mechanical University, Tallahassee, FL
- 2011 Reviewer, NIEHS Career Development Awards, Special Emphasis Panel/Scientific Review Group 2011/05 ZES1 LKB-J (K9)
- 2011-2016 Member, NIEHS National Advisory Environmental Health Sciences Council
- 2012 Member, Editorial Board, Journal of Alzheimer’s Disease
- 2015 Member and External Reviewer, School of Population and Public Health Review Committee, University of British Columbia, Vancouver, B.C.
- 2016- Chair, Board of Directors, Canadian Urban Environmental Health Research Consortium, (National Consortium based out of the Dalla Lana School of Public Health)
- 2017- Member, Energy Research Committee, Health Effects Institute, Boston, MA
- 2017-2018 Executive Co-Chair, Workshop on the Global Burden of Disease-Pollution and Health Initiative, March 1-2, 2018, Institute for Health Metrics and Evaluation, Seattle, WA
- 2017- Executive Co-Leader, Global Burden of Disease-Pollution and Health Initiative
- 2019- Member, Research Advisory Committee, Centre of Environmental Health, The Public

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20

- 2019 Health Foundation of India and the Tata Institute of Social Sciences, New Delhi, India
- 2019 Reviewer, draft report on trace metals levels in pregnancy women, Agency for Toxic Substances and Disease Registry, Centers for Disease Control and Prevention, Atlanta
- 2019 Reviewer, draft report on Concentration-Response Functions between Lead Exposure and Adverse Health Outcomes for Use in Benefits Analysis: Cardiovascular-Disease Related Mortality”, EPA National Center for Environmental Economics Office of Policy
- 2019- Member, Advisory Council, Physicians for Human Rights, New York, NY
- 2019 Reviewer, Special Emphasis Panel/Scientific Review Group 2020/01 ZES1 LAT-S (K9) Applications, Center for Scientific Review, U.S. National Institutes of Health
- 2019- Member, Board of Advisors Taskforce, Marilyn Brachman Hoffman Foundation, Dallas, TX
- 2020- Member, External Advisory Committee, New York University/NIEHS Environmental Health Core Sciences Centter, New York, NY
- 2020- Member, NIEHS DR2 Work Group SARS-CoV-2/COVID-19 Environmental Health Research Needs Panel.

Regional

- 1988-1990 Health Facilities Appeals Board, Member, Dept. Public Health, Comm. Of Mass.
- 1988-2006 Advisory Board, Massachusetts Department of Public Health, Sentinel Event Notification System for Occupational Risks (SENSOR) Project
- 1989-1995 Advisory Board, Massachusetts Division of Occupational Hygiene, Lead Registry Project
- 1990-1992 Board of Directors, Member, Health Care for All, Boston, Massachusetts
- 1993-1995 Faculty Council, Member, Harvard School of Public Health
- 1995-2006 Faculty Advisory Committee, Public Health Practice Program, Harvard School of Public Health
- 1996-2006 Advisory Board, Boston VA Environmental Hazards Center, Boston
- 1997-2001 Faculty Steering Committee, Center for Children's Health, Harvard School of Public Health
- 1996-2006 Senior Epidemiology Consultant, Massachusetts Veterans Epidemiology Research and Information Center, Boston.
- 1996-2006 Associate, Center for Health and the Global Environment, Harvard Medical School
- 1997-2002 Faculty Advisory Committee on Continuing Professional Education, Harvard School of Public Health
- 1998-2006 Faculty Steering Committee, Masters of Public Health program, Harvard School of Public Health
- 2001-2003 Board of Directors, New England College of Occupational and Environmental Medicine
- 2001-2006 Associate Director, Harvard NIEHS Environmental Sciences Center, Harvard School of Public Health
- 2001-2006 Senior Advisory Council Member, Lowell Center for Sustainable Production, University of Massachusetts, Lowell, MA
- 2003-2006 Member, Human Subjects Committee, Harvard School of Public Health
- 2003-2006 Advisory Committee, Occupational Health Services Research Program, Harvard School

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21

- of Public Health
- 2006 Study Section Review Committee, Pilot Project Program, Graham Environmental Sustainability Institute, School of Natural Resources and Environment, University of Michigan
- 2006-2007 Chair, Planning Committee, Health Sector, May 8-10, 2007 National Summit on Coping with Climate Change, University of Michigan
- 2007-2009 Member, Advisory Committee, SPH Practice Committee, University of Michigan School of Public Health
- 2007-2012 Member, Residency Advisory Committee, General Preventive Medicine Residency, University of Michigan School of Public Health
- 2008-2009 Member, Steering Committee, NIA T32 Training Grant on Aging Research (PI: Mary Haan), University of Michigan School of Public Health
- 2008-2013 Member, Advisory Committee, Outstanding New Environmental Scientist Awardee (Marie O'Neill), NIEHS
- 2008-2009 Member, Search Committee for Director of the Risk Science Center, University of Michigan School of Public Health
- 2009 Co-Chair, Planning Committee, Workshop on Predicting and Preventing Climate Change Impacts on Public Health, Goa, India (Collaboration with the UM Center for Global Health, the US Centers for Disease Control and Prevention, and the Indian Council for Medical Research)
- 2009-2011 Director and PI, NIA T32 Training Grant on Aging Research, University of Michigan School of Public Health
- 2009-2010 Member, Planning Committee, University Research Corridor (U of M, Michigan State, Wayne State) symposium on environmental health sciences in January 2010
- 2009-2012 Faculty Associate, Center for Global Health, University of Michigan
- 2009-2012 Member, Internal Advisory Board, Cancer Epidemiology Education in Special Populations Program, University of Michigan School of Public Health
- 2009-2011 Chair, Steering Committee on Global Health, University of Michigan School of Public Health
- 2010-2012 Member, Executive Committee, Graham Environmental Sustainability Institute, University Of Michigan
- 2010-2012 Member, Committee on Diversity, University of Michigan School of Public Health
- 2012-2017 Chair, Executive Committee, Dalla Lana School of Public Health, University of Toronto
- 2012-2017 Chair, Tenure Committee, Dalla Lana School of Public Health, University of Toronto
- 2012-2017 Chair, Decanal Promotions Committee, Dalla Lana School of Public Health, University of Toronto
- 2012-2017 Chair, Executive Advisory Committee, Institute for Global Health Equity & Innovation, Dalla Lana School of Public Health, University of Toronto
- 2013-2015 Interim Director, Institute for Global Health Equity & Innovation, Dalla Lana School of Public Health, University of Toronto
- 2013-2014 Co-Chair, Research Committee, Dalla Lana School of Public Health, University of Toronto
- 2014-2017 Chair, Executive Advisory Committee, Institute for Health Policy Management and Evaluation, University of Toronto

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22

- 2014 Chair, Ad-hoc Committee to create an Institute for Indigenous Health (based on a \$10 million endowment gift made to DLSPH), Dalla Lana School of Public Health, University of Toronto; Chair, Executive Advisory Committee beginning 2015
- 2015-2017 Chair, Executive Advisory Committee, Joint Centre for Bioethics, University of Toronto
- 2015- Chair (2015-2017); Member (2017-present), Taskforce on Environmental Health, Ministry of Health and Longterm Care, Province of Ontario
- 2016-2017 Chair, Executive Advisory Committee, Centre for Critical Qualitative Health Research, University of Toronto
- 2017-2018 Executive Co-Chair, Workshop on the Global Burden of Disease-Pollution and Health Initiative (a collaboration between the Global Alliance on Health and Pollution and the Institute for Health Metrics), Seattle, WA

Hospital

- 1982-1985 Occupational Safety and Health Committee, Member, Boston City Hospital, Boston
- 1983-1984 House Officers Association, Treasurer, Boston City Hospital
- 1984-1985 House Officers Association, Co-President, Boston City Hospital

OTHER PUBLIC SERVICE

- 1987 Member, Fact-finding tour on "The Health Effects of Massive Exposure to Tear Gas", Seoul, South Korea, July 11-18 (Sponsored by Physicians for Human Rights, American College of Physicians)
- 1988 Member, Fact-finding tour on "Chemical Weapons and the Iraqi Kurdish refugees", Turkey Oct 6-16 (Sponsored by Physician for Human Rights and the MacArthur Foundation)
- 1990 Leader, Fact-finding tour on "Health and Human Rights in Burma (Myanmar)", Thailand-Burma Dec. 26-Jan 6 (Sponsored by Physician for Human Rights and the MacArthur Foundation)
- 2009 Consultant and senior advisor, Fact-finding tour on "Mining and Potential Exposures and Health Effects in Guatemala", August 2009 (Sponsored by Physicians for Human Rights)

CONSULTING POSITIONS

- 1987-1989 Consultant, "In-Vivo Total Body Lead Analysis by X-Ray Fluorescence", NIH/SBIR Grant 2R44ES03918-02
- 1988-1989 Consultant, "Boston Area Health Coalition Demonstration Project", DHHS/MP000003-A1
- 1993-1995 Consultant, Employee Health Services, Brigham and Women's Hospital
- 1994 Consultant, Public Welfare Foundation, Washington, DC (review of Environmental Programs)
- 1997-2006 Consultant, Pediatric Environmental Health Center, Children's Hospital, Boston, MA

CV: Howard Hu, M.D., M.P.H., Sc.D.

CV: Howard Hu

23

- 2000 Consultant, Doris Duke Foundation, New York, NY (review of potential Environment and Medicine programs)
- 2009-2010 Consultant and Member, Academic Program Review Site Visit Committee, Department of Environmental and Occupational Health Sciences, University of Washington School of Public Health, Seattle, WA
- 2011 Consultant, JPB Foundation, New York, NY (review of Environmental Health programs)
- 2014-2016 Advisor, Hearing Health Sciences, Ann Arbor MI and Amsterdam, Netherlands
- 2020 Consultant on Environment, Pollution and Health, United Nations Environment Programme, Nairobi, Kenya

VISITING PROFESSORSHIPS

- 1997 Alice Hamilton Visiting Professor, University of California at San Francisco
- 2000-2001 Visiting Professor, Sri Ramachandra Medical College & Research Institute, Chennai, India
- 2004 Visiting Professor, Department of Environmental Medicine, University of Rochester
- 2013 Visiting Professor, Shanghai Key Laboratory, Shanghai Jiao-Tung University

SEMINARS AND EXTRAMURAL INVITED PRESENTATIONS (last 15 years, since 2004; prior presentations upon request)

- 2004 Speaker, "New Frontiers in Understanding the Toxicity of Lead", Department of Environmental Medicine, University of Rochester, Rochester, NY.
- 2003 Presenter, "Lead Exposure During Pregnancy: Mobilization of Maternal Bone Lead Stores and Their Threat to the Fetus", Semi-annual meeting of the Childhood Lead Poisoning Prevention Branch, Centers for Disease Control and Prevention, Baltimore, MD
- 2004 Presenter, "Environmental Medicine", Annual meeting of the Editorial Board, *Environmental Health Perspectives*, Baltimore MD
- 2003 Plenary speaker, "Metals, Genes, and Neurodegeneration: the Approach of the Metals Epidemiology Research Group at the Harvard School of Public Health", National Institute for Environmental Health Sciences Conference on Neurodegeneration.
- 2004 Discussant, "Suspected Lead Toxicity" Grand Rounds in Occupational/Environmental Medicine, Harvard School of Public Health
- 2004 Discussant, "Mercury Exposure in a Metal Worker", Grand Rounds in Occupational/Environmental Medicine, Harvard School of Public Health
- 2004 Presenter, "Effects of Our Environment on Intellect, Behavior, Life and Death," Leadership Council meeting, Harvard School of Public Health
- 2004 Guest Speaker, "Biomarkers, Genes, Interactions and Lead: New Insights from Research on an Old Hazard", Department of Environmental Health, University of Michigan School of Public Health
- 2004 Guest Speaker, "Medicine, Public Health, and the Great American Melting Pot: A Second-Generation Chinese-American Reflects on His Personal Odyssey", Sponsored by

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CV: Howard Hu

24

- the Asian Student Association, Harvard School of Public Health
- 2004 Speaker, “Aging, the Environment and Genetics: Recent Insights from Epidemiologic Studies of Environmental Lead Exposure”, Annual Leadership Retreat, National Institute for Environmental Health Sciences, Pinehurst, NC.
- 2004 Plenary Speaker, “Guidelines for the Management of Lead-Exposed Adults: Recommendations by a National Expert Panel Based on Recent Research”, New England College of Occupational and Environmental Medicine Annual Meeting
- 2004 Lecturer, “Biomarkers, Genes, Interactions and Lead: New Insights from Research on an Old Hazard”, Sri Ramachandra Medical College and Research Institute, Chennai, Tamil Nadu, India
- 2005 Lecturer, “Your Child’s IQ, Behavior and Neuropathology: Genes or Environment?”, the Harvard Club of Boston, Boston, MA
- 2005 Guest Speaker, “Metals, Neurodevelopment, and Neurodegeneration: The Work of the Metals Epidemiology Research Group at HSPH”, Neurostatistics Working Group, Harvard School of Public Health, Boston, MA.
- 2005 Plenary Speaker, “Aging, the Environment and Genetics: Recent Insights from Epidemiologic Cohort Studies of Environmental Lead Exposure”, NIEHS Symposium on Aging and the Environment, Duke University, Durham, NC.
- 2005 Plenary Speaker, “SPECT Imaging and Chemical Intolerance”, NIEHS/NIAA symposium on “Chemical Intolerance and Addiction: a Shared Etiology?”, Research Triangle Park, NC
- 2005 Workshop Presenter, “Social and Environmental Threats: the Unnecessary Epidemics”, Harvard School of Public Health Leadership Council Annual Conference, Boston, MA
- 2005 Keynote Speaker, “Our Food, Our Water, Our Homes: Toxic Metals”, The Boston Foundation, Boston, MA.
- 2006 Invited Speaker (invited by David Schwartz, NIEHS Director), “Goal IV: Improve and Expand Community-Linked Research”, Roundtable on Environmental Health Sciences, Research, and Medicine; Institute of Medicine, National Academy of Sciences, Wash DC.
- 2006 Speaker, “The Future of Environmental Health Sciences at the University of Michigan”, Dean’s Advisory Board, University of Michigan School of Public Health, Ann Arbor, MI
- 2006 Keynote Speaker and Harriett Hardy Annual Lecturer, “The ‘E’ in Occupational/ Environmental Medicine: the Present and the Future”, New England College of Occupational Medicine Annual Meeting, New Bedford, MA
- 2007 Speaker, “The Future of Environmental Health Sciences at the University of Michigan”, Meetings of the UMSPH Alumni Council and the EHS Emeritus Faculty, Ann Arbor, MI
- 2007 Moderator and Speaker, “The Normative Aging Study: Health Effects of Lead”, Symposium on the Health Effects of Lead, 2007 Annual Meeting of the International Society for Environmental Epidemiology, Mexico City, Sept 8, 2007
- 2007 Guest Lecture, “Uncovering the Impact of the Environment on Disease: Big Opportunities for Physician-Scientists”, Medical Scientist Training Program, University of Michigan Medical School
- 2007 Guest Lecture, “Industrialization, Pollution and Public Health in India: Can India Survive Modernization?”, Osher Institute, Ann Arbor, MI
- 2007 Plenary Speaker, “Environmental Equity: Local and Global Challenges and the Balance Between Research and Advocacy”, Michigan’s Premier Public Health Conference,

CV: Howard Hu, M.D., M.P.H., Sc.D.

CV: Howard Hu

25

- October 16, 2007, Dearborn, MI
- 2007 Board Member Lecture, "Metals, Genes, Health and Human Rights: from the Molecular to the Global", Fall Meeting of the Board of Population Health and Public Health Practice, Institute of Medicine, National Academies of Science, Washington DC, Dec 13, 2007.
- 2008 Speaker, "MDs as Leaders for Change in Environmentalism", 2008 Annual Regional Political Leadership Institute, American Medical Student Association, University of Michigan Medical School, February 16, 2008
- 2008 Speaker, Grand Rounds, "The Impact of Environmental Pollutants on Disease: New Insights and Implications for Research and Medical Practice" Department of Medicine, University of Michigan Health System.
- 2008 Guest Lecture, "Emerging Insights into the Pervasive Influence of Environment Toxicants on Reproductive Outcomes and Offspring Development: Lead as a Case Study", Reproductive Sciences Program, University of Michigan
- 2008 Panelist, "Environmental Health in China", Public Health Grand Rounds, Division of Health Practice, University of Michigan School of Public Health
- 2008 Keynote Speaker, "Human Health and the Role of Water", Symposium on Water, Health & The Environment, Graham Environmental Sustainability Institute, University of Michigan
- 2008 Guest Speaker, "Lead Exposure and Toxicity: New Insights Using Molecular Epidemiology" Wadsworth Laboratories and SUNY-Albany
- 2008 Speaker: "Impact of Climate Change on Human Health: Vulnerability" 5th AKKA World Kannada Conference, Chicago IL
- 2008 Speaker, "The 'E' in Occupational/Environmental Medicine: the Present and the Future", Michigan Occupational/Environmental Medicine Annual Meeting, Mackinac Island, MI
- 2008 Speaker, "Impact of Climate Change on Human Health", University of Michigan Chapter of the American Medical Student Association, Ann Arbor, MI
- 2008 Speaker, "Early Life Origins of Adult Chronic Disease: Environmental Health and Toxicology at a Crossroads" Michigan Chapter fo the Society for Toxicology, Ann Arbor, MI
- 2009 Speaker, "Evidence for Lead as an Environmental Stressor of Alzheimer's Disease and the Role of Epigenetics", Symposium Panel, Annual Meeting of the Society for Toxicology, Baltimore, MD
- 2009 Keynote Speaker, "Lead, Late-Life and Early Life Effects, and the Emerging Field of Environmental Epigenetics: Looking Ahead", Annual Meeting of the American College for the Advancement of Medicine, San Diego, CA
- 2009 Speaker, "Lead Toxicity and Mechanistically-Oriented Molecular Epidemiology: Targeting the Epigenetics of Alzheimer's Disease", Seminar Series, Institute for Environmental Health Sciences, Wayne State University, Detroit, MI
- 2009 Speaker, "Climate Change Impacts on Health in the Developing World", Research Discussion Series, University of Michigan Center for Global Health
- 2009 Speaker, "Autism, Aggressive Behavior, Anxiety, and Alzheimer's: are Environmental Toxicants Playing a Major Etiologic Role?", Department of Psychology, University of Michigan
- 2009 Speaker, "Early Life Exposures and Endocrine Disruption: Evidence from Molecular Epidemiology", Pediatric Endocrine Seminar, University of Michigan Medical School

CV: Howard Hu, M.D., M.P.H., Sc.D.

CV: Howard Hu

26

- 2009 Distinguished Speaker, “Lead Toxicity: Twenty Years of Research On The Poison That Keeps on Poisoning” 10th Anniversary of the Department of Microbiology and Environmental Toxicology, University of California at Santa Cruz
- 2010 Speaker, “The Centers for Disease Control and Prevention & the Environmental Protection Agency: Potential Funding Opportunities for Regional Collaboration in Michigan”, University Research Corridor Symposium on Environmental Health, Detroit, MI.
- 2010 Speaker, “The Future of Public Health”, University of Washington School of Public Health
- 2010 Speaker, “The Environment Meets the Epigenome: Is This Where Autoimmunity Begins?” Symposium on Autoimmunity and Epigenetics, University of Michigan
- 2010 Keynote Speaker, “A New Twist to an Old Story: The Evidence for Early Life Lead Exposure as a Risk Factor for Alzheimer's Disease through Epigenetic Programming”, NIEHS Environmental Health Sciences Center and Toxicology Training Program Retreat, University of Rochester, NY
- 2010 Speaker, “Lead Toxicity: Twenty Years of Research on The Poison That Keeps on Poisoning” and “Environmental Health Sciences at the University of Michigan”, Tianjin Centers for Disease Control, Tianjin, China
- 2010 Speaker, “Pediatric Lead Toxicity”, Xinhua Hospital and the Shanghai Jiao-Tung Medical University Department of Pediatrics, Shanghai, China
- 2010 Speaker, “Environmental Health Sciences at the University of Michigan”, Fudan University, Shanghai, China
- 2010 Speaker, “Alzheimer’s Disease, Epigenetics and the Environment”, Symposium Update, Alzheimer’s Disease Association, Ann Arbor, MI
- 2010 Speaker, “Environmental Justice, Progress (and the Lack Thereof) and the Role of Research”, Roundtable on Environmental Health Sciences, Research and Medicine, Institute of Medicine, National Academies, Washington DC.
- 2010 Speaker, “White Coats, Population Science and Poison Gas: A Life Spent at the Intersection of Academic Medicine, Global Health & Human Rights”, Robert Wood Johnson Clinical Fellows Program, University of Michigan Medical School, Ann Arbor, MI
- 2011 Speaker, “The Three Most Difficult Challenges to Molecular Epidemiologic Research on Gene-Environment Interactions: Lead Toxicity as a Case Study.” Department of Human Genetics, University of Michigan Medical School, Ann Arbor, MI
- 2011 Speaker, “The Integration of Data on Environmental Carcinogens with Population and Genetic Resources”, “Opportunities & Challenges for Translational Research on Cancer Prevention”, Translational Cancer Prevention & Biomarkers Workshop, Mazamdur-Shaw Cancer Center, Bangalore, India.
- 2011 Speaker, “Success in the Academy”, Faculty Panel, Students of Color of Rackham, Rackham Graduate School, University of Michigan
- 2011 Speaker, “White Coats, Population Science and Poison Gas: Fact-Finding Missions by Health Professionals for Human Rights”, Sujal Parikh Memorial Symposium, University of Michigan Medical School.
- 2011 Speaker, “The Analysis of Biomarker Data to Ascertain the Contribution of Environmental Exposures to the Etiology of Disease: Lead Exposure and Toxicity as a Case Study”, Department of Computational Medicine and Bioinformatics, University of Michigan Medical School.

CV: Howard Hu, M.D., M.P.H., Sc.D.

CV: Howard Hu

27

- 2012 Speaker, “Research and Analysis Linking Upstream and Downstream Disparities Work”, Webinar hosted by the Health & Environmental Funders Network, Bethesda, MD, with 52 Foundations related Health.
- 2012 Keynote Speaker, “The Future of Public Health & Medicine in a Crowded, Diverse, Stratified, Hot, Urbanized, Polluted, Thirsty, Hungry and Debt-Ridden World”. E.J. Van Liere Memorial Convocation and Health Sciences Center Research Day, West Virginia University, Morgantown, West Virginia
- 2012 Plenary Speaker, “Transgenerational Impacts of Pollutants on Offspring: Recent Insights and Case Studies”, Connaught Global Challenge International Symposium, University of Toronto.
- 2012 Speaker, “Environmental Impacts on Aging (+ an update on the Dalla Lana School of Public Health)”, Community Medicine Rounds, University of Toronto
- 2012 Speaker, “The Environment & Public Health in a Research-Intensive University: Opportunities for Scholarship in a Crowded, Diverse, Stratified, Hot, Urbanized, Polluted, Thirsty, Hungry and Debt-Ridden World”, School for the Environment, University of Toronto
- 2012 Speaker, “Big Public Health Challenges (& Opportunities) in a Crowded, Diverse, Aging, Stratified, Urbanized, Polluted, Hot, Thirsty, Hungry, Debt-Ridden World”, External Advisory Meeting, Public Health Ontario, Toronto
- 2012 Speaker, “Canadian Public Health Schools (in a Crowded, Diverse, Aging, Stratified, Urbanized, Polluted, Hot, Thirsty, Hungry, Debt-Ridden World): The View from Toronto, External Advisory Board Meeting, Institute for Population and Public Health, Canadian Institutes for Health Research, Toronto
- 2012 Speaker, “Sustainable Development and Health: The Global Mining Industry”, Canadian Society for International Health Annual Meeting, Ottawa
- 2012 Speaker, “Big Public Health Challenges (& Opportunities) in a Crowded, Diverse, Aging, Stratified, Urbanized, Polluted, Hot, Thirsty, Hungry, Debt-Ridden World”, Xinhua Hospital/Shanghai Jiao-Tung University, Shanghai, China.
- 2012 Speaker, “The Impact of Population-Wide Lead Exposure and Gene-Lead Interactions on Chronic Disease”, Genetic Grand Rounds, Sick Kids Hospital, Toronto.
- 2012 Speaker, “Looking behind the curtain: Lead Toxicity as a Case Study of Methodologic Challenges in Gene-Environment Interactions Research”, Strategic Training in Advanced Genetic Epidemiology (STAGE), Dalla Lana School of Public Health, University of Toronto.
- 2012 Keynote speaker: “Public Health—the Next Frontier in Health Professions Education”. Council of Health Sciences annual retreat, University of Toronto.
- 2013 Speaker, “White Coats, Population Science and Poison Gas: Lessons from a Life Spent at the Intersection of Academic Medicine, Global Health & Human Rights”, Joint Center for Bioethics, University of Toronto
- 2013 Speaker, “Gauging environmental impact on the development of chronic inflammation”, Connaught Global Challenge Workshop, University of Toronto.
- 2013 Speaker, “The Future of Public Health & Medicine in a Crowded, Diverse, Aging, Stratified, Urbanized, Polluted, Hot, Thirsty, Hungry, Debt-Ridden World”, Grand Rounds, Department of Medicine, University of Toronto.
- 2013 Speaker, “Metals, Mega-trends, and Me: Reflections on Research and the Vision for the

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CV: Howard Hu

28

- Dalla Lana SPH”, Occupational and Environmental Medicine Grand Rounds, St. Michael’s Hospital, Toronto, ON.
- 2013 Speaker: “Air pollution and Cardiovascular Disease: Health Impacts, Mechanisms, and Research Opportunities”, University of Toronto & FMUSP-InCor Symposium on Cardiology, Sao Paulo, Brazil.
- 2013 Speaker: “Lead Exposure’s Impact on Health and Policy: A History of Neglect and Missed Opportunities”, Public Health Policy Rounds, CIHR Strategic Training Program in Public Health Policy, University of Toronto.
- 2013 Speaker: “Lead Toxicity: The Long Tail of Health Impacts (and On-going Research Opportunities!) From an Historical Environmental Air Pollutant”, Southern Ontario Centre for Air Pollution and Aerosol Research, University of Toronto.
- 2013 Speaker: “Water and Sanitation”, Water, Sanitation and Hygiene (WASH) Canada, Toronto, Ontario, Canada
- 2014 Speaker: “Conflict and Public Health”, Ontario Medical Association, Toronto, Canada
- 2014 Panelist: “Judging Evidence: Finding a Place for Variation in an Evidence-Based World”, Health Quality Ontario, Toronto, Canada
- 2014 Speaker: “The Grand Convergence: Creating Health in a Globalized World”, Special meeting of the Canadian Chamber of Commerce in Shanghai
- 2014 Speaker: “The Grand Convergence: Creating Health in a Globalized World”, Jockey School of Public Health and Primary Care, Chinese University of Hong Kong, Hong Kong, China
- 2015 Speaker: “The Grand Convergence: Creating Health in a Globalized World”, School of Public Health and the ASEAN Institute, Mahidol University, Bangkok, Thailand
- 2015 Speaker: “Gene-environment Interactions and the Role of Big Data in Environmental Health” Seminar series, School of the Environment, University of Toronto, Toronto, Canada
- 2015 Speaker: “Global Health Security”, Ill with Illness—Economic, Social & Security Barriers to the Provision of Global Health, Munk School of Global Affairs, University of Toronto, Toronto, Canada
- 2015 Speaker: “The Dalla Lana School of Public Health: Big Ideas and Initiatives for Creating Health in a Globalized World”, Speaker Series, University of Toronto Alumni of Toronto.
- 2015 Speaker: “Unique Scientific Opportunities for the Precision Medicine Initiative National Research Cohort: Exposomics, Data Linkage, and Global Collaborations”. Working group on President Obama’s Precision Medicine Initiative (Chaired by Francis Collins, Director, NIH)
- 2015 Speaker: “What is the Role of Schools of Public Health in the 21st Century?” 50th Anniversary Celebration of the Department of Epidemiology, Biostatistics and Occupational Health, McGill University, Montreal, Quebec.
- 2015 Welcoming Address: “Global Public Health and Mental Health”, Going Global for Mental Health conference, Centre for Addictions and Mental Health/Department of Psychiatry/Dalla Lana School of Public Health, Toronto, ON
- 2015 John Goldsmith Memorial Lecture: “Big Data, Environmental (and Social) Epidemiology, Power and Politics”, Opening Plenary Session, International Society for Environmental Epidemiology Annual Meeting, Sao Paulo, Brazil
- 2015 Inaugural Speaker: “The Future of Public Health and Medicine in a Crowded and Complex World”, Global Health Leadership Series, PSG Medical School & the Shanti Ashram Foundation, Coimbatore, Tamil Nadu, India

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CV: Howard Hu

29

- 2016 Speaker “The Future of Public Health & Medicine in a Crowded, Diverse, Aging, Stratified, Urbanized, Polluted, Hot, Thirsty, Hungry, Debt-Ridden World”, Indian Institutes of Public Health—Hyderabad, Hyderabad, India
- 2016 Speaker: “Integration of Public Health & Health Care: The Unmet Agenda for a Truly Sustainable Health System”, Board of Directors Retreat, Toronto East General Hospital, Toronto
- 2016 Plenary speaker: “Health Promotion, Prevention and Health Protection: Innovative Initiatives”, 6th Asia-Pacific Conference on Public Health | 1st ASEAN Health Promotion Conference Bangkok, August
- 2016 Speaker: “Big Data, Environmental (and Social) Epidemiology, Power and Politics”, Mount Sinai School of Medicine, New York, NY
- 2016 Plenary Speaker: “The Impact of Environmental Toxicants on Health: Recent Epidemiologic Approaches & Advances”, International College of Integrative Medicine Annual Meeting, Toronto, ON
- 2016 Plenary Speaker: “Big Data and Implications for Environmental Health”, 15th Anniversary Conference, Jockey Club School of Public Health & Primary Care, Chinese University of Hong Kong, Hong Kong
- 2016 Plenary Speaker: “Innovations in Assessing Lead Poisoning and Child Health: Policy & Clinical Implications”, Chinese University of Hong Kong-Fudan-Oxford International Symposium on Health Impacts of Environmental Exposures”, Hong Kong
- 2016 Speaker: “Addressing a Changing Environment (and Impacts on Health, AKA Can India Survive Modernization?)”, Indian Institutes of Technology Alumni, Canada, International Conference 2016, Toronto.
- 2016 Plenary Speaker, “Hidradenitis Suppurativa: Research Directions from a Population Health Perspective”, Symposium on Hidradenitis Suppurativa Advances, Toronto.
- 2016 Plenary Speaker, “Children’s Environmental Health”, The 2016 Annual National Conference on Children’s Healthcare, Shanghai, China
- 2016 Special Guest Speaker, “Big Data, Environmental (and Social) Epidemiology, Power and Politics”, Shanghai Municipal Center for Disease Control, Shanghai, China
- 2016 Lecturer, “Lead and Human Health: Recent Research and Associated Lessons for Science & Policy”, Fudan University School of Public Health, Shanghai, China
- 2017 Lecturer, “The Impact of Environmental Toxicants on Health: Recent Epidemiologic Approaches & Advances”, Saw Swee Hock School of Public Health, National University of Singapore, Singapore
- 2017 Lecturer, “The Future of Academic Public Health”, Saw Swee Hock School of Public Health, National University of Singapore, Singapore
- 2017 Lecturer, “Recent Advances in Understanding, Preventing, and Reversing the Impact of Environmental Factors on Health”, Society of Chinese Bioscientists in America, Li Ka Shing Knowledge Institute, St. Michael’s Hospital, Toronto, ON
- 2017 Lecturer, “Environmental Epidemiology in the Era of Exposomics, Lifecourse Epidemiology, Big Data and Big Science”, Department of Environmental Health, Harvard School of Public Health, Boston, MA
- 2017 Speaker, “The Role of a Re-emergent Canadian School of Public Health in a Hot, Hungry, Polluted, Aging, Polarized World Prone to Pandemics, Chronic Disease, and Unsustainable

CV: Howard Hu, M.D., M.P.H., Sc.D.

CV: Howard Hu

30

- Health Systems”, Royal Canadian Institute for Science, Toronto, ON
- 2017 Speaker, “The Early Life Exposures in Mexico to Environmental Toxicants (ELEMENT) Birth Cohort Study: Current Research on Fluoride and Neurodevelopment”, Seminar Series in Environmental Epidemiology, University of Washington School of Public Health, Seattle, WA
- 2017 Plenary Speaker: “New realities arising from the extractive industries and agri-business: the Pollution and health perspective,” Hong Kong Summit of Global Health Leaders. University of Hong Kong, Hong Kong
- 2018 Plenary Speaker: “The GBD-Pollution and Health Initiative: Challenges & Opportunities”, Workshop on the Global Burden of Disease-Pollution and Health Initiative, Institute for Health Metrics, University of Washington, Seattle, WA
- 2018 Guest Lecturer: “Partnerships, Local Responsiveness, National and Global Impacts”, University of Iowa College of Public Health, Iowa City, IA
- 2018 Plenary Speaker: “Current Research on Fluoride and Neurodevelopment: The Early Life Exposures in Mexico to Environmental Toxicants (ELEMENT) Birth Cohort Study”, Annual meeting of the International Academy of Oral Medicine and Toxicology, Denver, CO
- 2018 Speaker, “Recent Epidemiologic Research on Lead Toxicity: New Surprises regarding an Old Global Pollutant”, Department of Environmental and Occupational Health Sciences Seminar Series, University of Washington School of Public Health, Seattle, WA
- 2018 Speaker: “The Early Life Exposures in Mexico to Environmental Toxicants (ELEMENT) Birth Cohort Study: Current Research on Fluoride and Neurodevelopment”, Symposium on Fluoride research, Annual meeting of the International Society for Environmental Epidemiology/International Society for Exposure Science, Ottawa, ON
- 2018 Panelist, “The Fluoridation Decision: Considering the Evidence for Benefits, Possible Risks as well as Ethical World Views”, Annual meeting of the International Society for Environmental Epidemiology/International Society for Exposure Science, Ottawa, ON
- 2018 Speaker: “Grand Opportunities”, The UC-Irvine School of Population Health and the Samueli College of Health Sciences, Irvine, CA
- 2018 Speaker, “The Global Burden of Disease-Pollution and Health Initiative”, Office of the Director and the Global Environmental Health Program, U.S. National Institute for Environmental Health Sciences, Research Triangle Park, NC
- 2019 Speaker, “Evaluating, treating and managing disabilities of patients with chemical intolerance”, Symposium on Chemical Intolerance—A Way Forward, Marilyn Brachman Hoffman Foundation and the Hoffman Program on Chemicals and Health at the Harvard T.H. Chan School of Public Health, Dallas, TX
- 2019 Guest Lecturer: “The Global Burden of Disease-Pollution and Health Initiative”, Center for Population Health Sciences, Stanford University, Palo Alto, CA
- 2019 Guest Lecturer: “Lead and Fluoride: Old and New Toxicant Issues and the Global Burden of Disease”, British Columbia Centre for Disease Control, Vancouver, BC, Canada
- 2019 Guest Lecturer: “Lead and Fluoride: Old and New Toxicant Issues and the Global Burden of Disease”, University of California, Davis, CA, USA
- 2019 Symposium Speaker, “A Framework for Adding Environmental Exposure-Outcome Pairs to the Global Burden of Disease: The Global Burden of Disease-Pollution and Health Initiative”, 2019 Annual Meeting of the International Society for Environmental

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CV: Howard Hu

31

- Epidemiology, Utrecht, Netherlands
- 2019 Workshop speaker, “The Global Burden of Disease – Pollution and Health Initiative: Impacts on Human Capital”, Air Pollution, Health and Human Capital Nexus in Chinese Cities Scoping Meeting, Institute of Urban Environments, Chinese Academy of Sciences, Xiamen, China
- 2019 Speaker, “Toxic Chemicals, Human Health, and Human Rights”, A Human Right to Health: Pathways and Responses, Seattle University Law School, Seattle, WA
- 2020 Guest Lecturer: “The Herbert Wertheim School of Public Health at UC San Diego: Grand Opportunities.” University of California at San Diego, San Diego, CA

INVENTIONS/PATENTS: n/a

BIBLIOGRAPHY: (H-index, as of March, 2020, Google Scholar: 88; 39,899 citations)

NCBI : <https://www.ncbi.nlm.nih.gov/myncbi/1vwnVYvgxEAw/bibliography/public/>

Peer-reviewed journals

1. Hu H, Markowitz SB. A case-study of industrial bladder cancer. Einstein Quarterly Review of Biology and Medicine 1982;1:29-35.
2. Hu H. Benzene and myelofibrosis. Annals of Internal Medicine 1987;106:171-172
3. Hu H, Milder FL, Burger DE. X-Ray Fluorescence: Issues surrounding the application of a new tool for measuring burden of lead. Environmental Research 1989;49:295-317.
4. Hu H, Fine J, Epstein P, Kelsey K, Reynolds P, Walker B. Tear Gas: Harrassing agent or toxic chemical weapon? JAMA 1989;262:660-663.
5. Hu H, Cook-Deegan R, Shukri A. The use of chemical weapons: Conducting an investigation using survey epidemiology. JAMA 1989;262:640-643.
6. Hu H, Tosteson T, Aufderheide AC, Wittmers L, Burger DE, Milder FL, Schidlovsky G, Jones KW. Distribution of lead in human bone: I. Atomic absorption measurements. Basic Life Sci 1990;55:267-274.
7. Burger DE, Milder FL, Morsillo PR, Adams BB, Hu H. Automated bone lead analysis by k-x-ray fluorescence for the clinical environment. Basic Life Sci 1990;55:287-292.
8. Schidlovsky G, Jones KW, Burger DE, Milder FL, Hu H. Distribution of lead in human bone: II. Proton microprobe measurements. Basic Life Sci 1990;55:275-280.

CV: Howard Hu, M.D., M.P.H., Sc.D.

CV: Howard Hu

32

9. Jones KW, Schidlovsky G, Burger DE, Milder FL, Hu H. Distribution of lead in human bone: III. Synchrotron x-ray microscope measurements. *Basic Life Sci* 1990;55:281-286.
10. Hu H, Milder FL, Burger DE. X-ray fluorescence measurements of lead burden in subjects with low-level community lead exposure. *Arch Environ Health* 1990;45:335-341.
11. Hu H, Win KU, W, Arnison ND. Burma: Health and human rights. *Lancet* 1991;337:1335.
12. Hu H. A 50-year follow-up of childhood plumbism: hypertension, renal function, and hemoglobin levels among survivors. *Am J Dis Child* 1991;145:681-687.
13. Hu H. Knowledge of diagnosis and reproductive history among survivors of childhood plumbism. *Am J Publ Health* 1991;81:1070-1072.
14. Hu H, Milder FL, Burger DE. The use of K-X-Ray Fluorescence for measuring lead burden in epidemiological studies: high and low lead burdens and measurement uncertainty. *Environ Health Perspect* 1991;94:107-110.
15. Hu H, Pepper L, Goldman R. Effect of repeated occupational exposure to lead, cessation of exposure, and chelation on levels of lead in bone. *Am J Ind Med* 1991;20:723-735.
16. Hu H. Toxic weapons, epidemiology, and human rights. *Polit Politics and Life Sci* 1992;February:3-4.
17. Hu H, Sparrow D, Weiss S. Association of serum albumin with blood pressure in the Normative Aging Study. *Am J Epidemiol* 1992;136:1465-1473.
18. Hu H, Christiani D. Reactive airways dysfunction after exposure to tear gas. *Lancet* 1992;339:1535.
19. Hu H. Physicians, IPPNW, and the Environment. *PSR Quarterly* 1993;3:79-87.
20. White RF, Diamond R, Proctor S, Morey C, Hu H. Residual cognitive deficits 50 years after lead poisoning during childhood. *Br J Industr Med* 1993;50:613-622.
21. Hu H, Beckett L, Kelsey K, Christiani D. The left-sided predominance of asbestos-related pleural disease. *Am Rev Resp Dis* 1993;148:981-984.
22. Payton M, Hu H, Sparrow D, Young JB, Landsberg L, Weiss ST. Relation between blood lead and urinary biogenic amines in community-exposed men. *Am J Epidemiol* 1993;138:815-825.
23. Hu H, Kotha S. Ethics and epidemiology: International Guidelines. *Polit Life Sci* 1993;February:29-30.

CV: Howard Hu, M.D., M.P.H., Sc.D.

CV: Howard Hu

33

24. Goldman RH, White R, Kales SN, Hu H. Lead poisoning from mobilization of bone stores during thyrotoxicosis. *Am J Industr Med* 1994;25:417-424.
 25. Bellinger D, Hu H, Titlebaum L, Needleman HL. Attentional correlates of dentin and bone lead levels in adolescents. *Arch Environ Health* 1994;49:98-105.
 26. Watanabe H, Hu H, Rotnitzky A. Correlates of bone and blood lead levels in carpenters. *Am J Industr Med* 1994;26:255-264.
 27. Hu, H. Decision-making in human health impact assessments: a clinician's perspective. *Environ Impact Assess Rev* 1994;14:439-450.
 28. Hu H, Watanabe H, Payton M, Korrick S, Rotnitzky A. The relationship between bone lead and hemoglobin. *JAMA* 1994;272:1512-1517.
 29. Payton M, Hu H, Sparrow D, Weiss ST. Low-level lead exposure and renal function in the Normative Aging Study. *Am J Epidemiol* 1994;140:821-829.
 30. Aro ACA, Todd AC, Amarasiwardena C, Hu H. Improvements in the calibration of ¹⁰⁹Cd K x-ray fluorescence systems for measuring bone lead *in vivo*. *Phys Med Biol* 1994;39:2263-2271.
 31. Guo H-R, Chiang H-S, Hu H, Lipsitz SR, Monson RR. Arsenic in drinking water and urinary cancers: a preliminary report. *Environ Geochem Health* 1994;s16:119-128.
 32. Hoppin JA, Aro ACA, Williams PL, Hu H, Ryan PB. Validation of K-xrf bone lead measurements in young adults. *Environ Health Perspect* 1995;103:78-83.
 33. Smith CM, Wang X, Hu H, Kelsey KT. A polymorphism in the δ -Aminolevulinic acid dehydratase gene may modify the pharmacokinetics and toxicity of lead. *Environ Health Perspect* 1995;103:248-253.
 34. Hu H, Aro A, Rotnitzky A. Bone lead measured by X-ray fluorescence: Epidemiological methods. *Environ Health Perspect* 1995;103(Suppl 1):105-110.
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44

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54

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CV: Howard Hu

64

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65

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66

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69

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CV: Howard Hu

70

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CV: Howard Hu

72

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CV: Howard Hu

73

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Abstracts of Work (Upon request)

CV: Howard Hu, M.D., M.P.H., Sc.D.

EXHIBIT 2

Howard Hu, M.D., M.P.H., Sc.D.

List of all publications authored by Dr. Hu, or on which Dr. Hu is listed as an author, in the previous 10 years.

A. Original articles in peer-reviewed journals

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EXHIBIT 3

Howard Hu, M.D., M.P.H., Sc.D.

Consultant in Occupational and Environmental Medicine & Epidemiology¹

Depositions, Trials, in US federal or state court cases, the last 5 years (2015-present, as of May, 2020)

DESCRIPTION: In each of these cases, Dr. Hu served as either a consultant in occupational and environmental medicine & epidemiology who evaluated a particular patient and rendered an expert opinion, and/or as a consultant in occupational and environmental medicine & epidemiology who reviewed the literature on a particular issue with respect to causality and rendered a scientific opinion.

DATE	TYPE	CASE	CLIENT
8/17/17	Deposition	Buckler v. JCI	Burg, Simposon, Eldredge, Hersh, Jardine PC, Attorneys at Law, Englewood, CO
5/16/19	Deposition	A.O.A., et al. v. Doe Run Resources Corporation, et al., Case No. 4:11-CV-00044-CDP	Schlichter, Bogard & Denton, LLP, St. Louis, MO
9/16/19-9/17/19	Deposition	Don Strong et al., v. Republic Services, Inc., et al.	Humphrey, Farrington & McClain, P.C., Independence, MO
9/24/19	Deposition	Food & Water Watch, Inc., et al, v. United States Environmental Protection Agency (US EPA), et al.	Non-retained expert, testifying on the work and results of my epidemiologic research team on the potential neurodevelopmental impacts of fluoride, in response to subpoena from the U.S. EPA., arranged by Waters Kraus Paul, P.C., Segundo, CA
10/9/19	Deposition	Pamela Butler, et al. v. Mallinckrodt, Inc., et al.	Humphrey, Farrington & McClain, P.C., Independence, MO
2/8/20	Trial	USA v. Gary Spengler, M.D.	Oberheiden & McMurrey, Dallas, TX 75240

¹ Current academic position, as of July 1, 2020: Professor and the Flora L. Thornton Chair of the Department of Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, CA.

EXHIBIT 4

Howard Hu, M.D., M.P.H., Sc.D.

Consulting Expert in Occupational/Environmental Medicine, Internal Medicine & Epidemiology

Affiliate Professor, University of Washington

LinkedIn: <https://www.linkedin.com/in/howard-hu-059703a/>

Consultant contact: 12544 42nd Avenue, Seattle, WA, 98125, USA

Email: howardhu2225@gmail.com

Consulting rates for legal expert work, as of January 2018

Pre-deposition and pre-trial work (reviewing documents, analyzing data, preparing reports, communications, etc.)

\$600 US/hr

Deposition testimony

\$1,000 US/hr

Trial testimony (at relevant location)

\$8,000 US/day + travel expenses

Travel: \$200 US/hr (door to door)

NOTE: Payments to be submitted as checks in USD from a US-based bank account or wire transfers to a U.S. bank account

EXHIBIT 5

LIST OF REFERENCES

<u>Exhibit</u>	<u>Description</u>
1	Flint Water Advisory Task Force. <i>Final Report, Flint Water Advisory Task Force</i> . March, 2016. Office of Governor Rick Snyder, State of Michigan.
2	Government of Michigan. <i>Flint Community Schools Initial Screening Results (Oct. 2, 2015)</i> . Available at https://www.michigan.gov/documents/deq/Flint_Community_Schools_Testing_Results_Initial_Screen_502382_7.pdf ; accessed on April 16, 2020.
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